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L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT — DANEMARK

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ET
PROCÈS-VERBAUX DES RÉUNIONS

VOLUME CVII

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APPENDICES

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ENCLOSURE

for separate collection with future plankton sheets.

F. S. Russell: Chaetognatha I. 1938. Zooplankton Sheets.

CHAETOGNATHA I

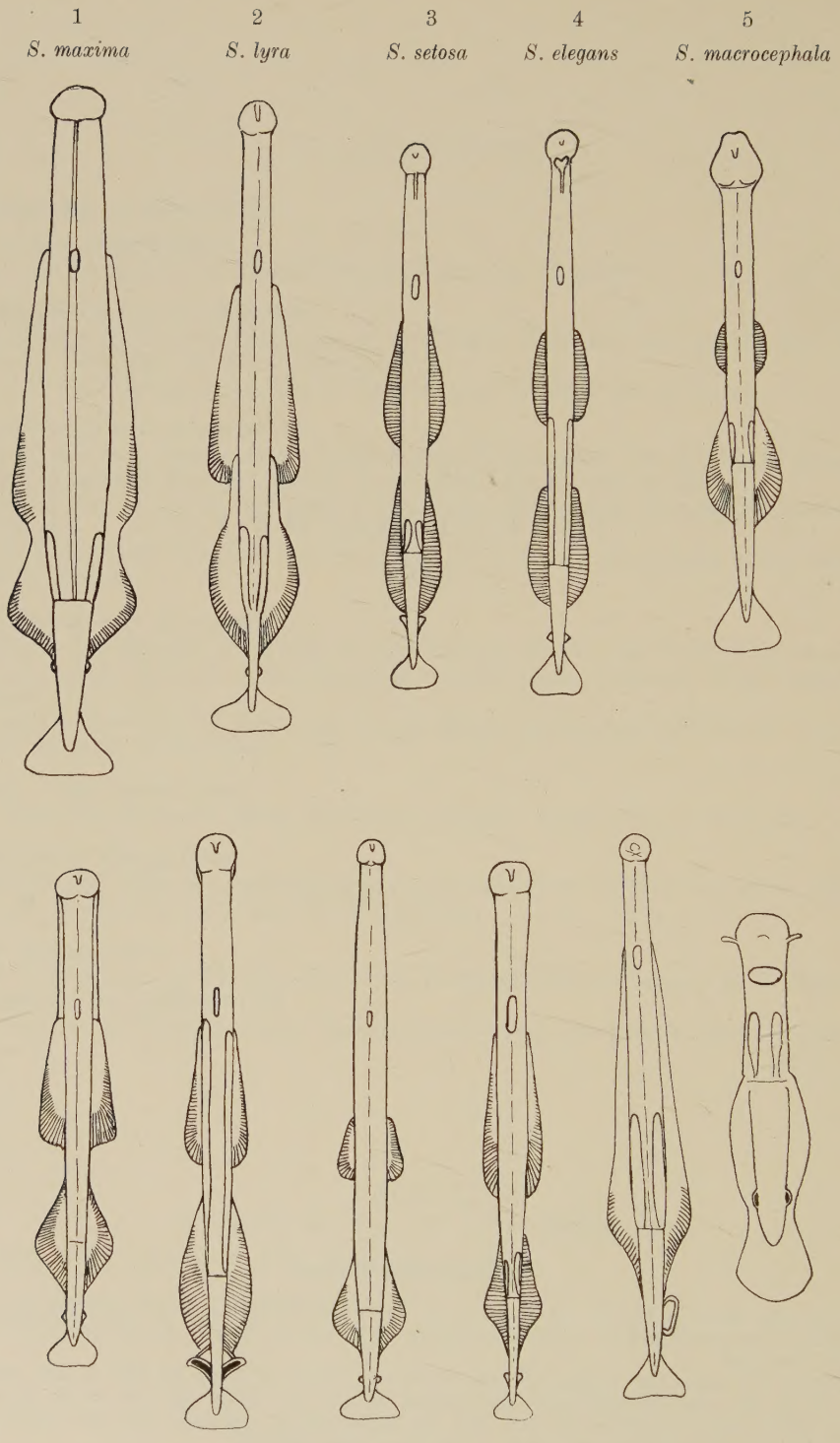
1938.

Zooplankton Sheets.

The object of this sheet is not to serve as a short cut to identification, but to prevent the unnecessary waste me and possible errors introduced by a plankton worker (who has to identify all groups) in finding his way to the authoritative literature.

The distribution will show the worker at once which species he is likely to find in the area from which the ctions come. From the identification table and figures he can see which are the most obvious characters for tification. This preliminary identification can then be confirmed or otherwise by the "notes on further identi-ion" and comparison with descriptions given in the references quoted.

The sheets should be dated and periodically brought up to date or supplemented with additional sheets as new ks are published. In this way they will gradually become completed with references to work on larval stages life histories etc., and any changes in nomenclature, splitting of species, or additions of new species will be ght to the notice of plankton workers.



1 *S. maxima*
2 *S. lyra*
3 *S. setosa*
4 *S. elegans*
5 *S. macrocephala*
6 *S. planctonis*
7 *S. serratodentata*
8 *S. hexaptera*
9 *S. decipiens*
10 + 11 *Eukrohnia*
12 *Spadella*

(Figures not all to same scale)

Genus SAGITTA Quoy and Gaimard.

Two pairs of lateral fins.

Species	Fins	Rays on Fins	Head	Collarette	Jaws and Teeth	Vesiculae seminales	Alimentary diverticula	Maximum size mm.	Remarks
a (CONANT) ...	Joined	Partial	Broad	—	—	—	—	ca. 50	Anterior fin begins in front of ganglion
KROHN	,,	,,	—	—	—	—	—	38	Anterior fin begins behind ganglion
J. MÜLLER	Separate	Complete	—	—	—	Wedgeshaped	Absent	20	Transparent when preserved
VERRILL	,,	,,	—	—	—	Conical	Present	ca. 25	Opaque when preserved
cephala FOWLER	,,	Partial	Very large	—	—	—	—	37	—
onis STEINHAUS	,,	,,	—	Well developed	Teeth long, directed backwards	—	—	ca. 25	—
dentata KROHN	,,	,,	—	—	Jaws serrated	Large elongate	—	17	—
era D'ORBIGNY	,,	,,	—	—	2 or 3 long teeth directed forwards	—	—	70	Small anterior fin
ens FOWLER ...	,,	,,	—	—	—	—	—	20	Long anterior fin

Genus EUKROHNIA Ritter-Záhony.

One pair of lateral fins, partly on body and on tail segment.

a (MÖBIUS) — no pigment in eyes; jaws 8—10; ca. 30 mm.
RITTER-ZÁHONY — black pigment in eyes; jaws 11—13; red when alive.

Genus SPADELLA Langerhans.

One pair of lateral fins, entirely on tail segment.

optera (BUSCH) — not strictly planktonic.

Further Notes on Identification and References

cima. Rather soft and stout; transparent; tail segment 19—32% of length. No collarette; no alimentary diverticula. RITTER-ZÁHONY, 1910a, Figs. 7, 8, 10.
. Rather soft and stout; transparent, tail segment 14—21% of body . No collarette; no alimentary diverticula. BURFIELD and HARVEY, Pl. 5, Figs. 18—24; RITTER-ZÁHONY, 1911b, Fig. 8, 1911c, Figs. 3, 8.
sa. Notes in table sufficient for identification; vesiculae seminales close touching posterior lateral fin. RITTER-ZÁHONY, 1911a, Figs. 1—3.
ans. Has three varieties, *elegans*, *arctica* (reaching 50 mm.) and *baltica*. R-ZÁHONY, 1910a, Pl. 5, Figs. 1c, 1d, 2, 5 (as *bipunctata*); 1911a, 5—7; 1911b, Figs. 1—3; 1911c, p. 15; HUNTSMAN, 1919.
rocephala. Slender, stiff species; no collarette; no alimentary diverti- 20—40 brown posterior teeth; gut red when alive. FOWLER 1905, RITTER-ZÁHONY, 1911c, Figs. 37, 38.
ctonis. Opaque species, robust and stiff; large conical vesiculae semi- BURFIELD and HARVEY, 1926, Pl. 5, Fig. 28, Pl. 6, Fig. 29; RITTER- NY, 1911c, Figs. 32—36.
atodentata. The only species with serrated teeth, but serrations may y weak or absent; rather transparent; slender; stiff; short collarette; mentary diverticulae. RITTER-ZÁHONY, 1909; 1911c, Figs. 21, 22; R, 1937.
ptera. Stout transparent; no collarette; no alimentary diverticula. ER, 1906; RITTER-ZÁHONY, 1908, 1911b, Figs. 6, 7.
piens. Short collarette; alimentary diverticula present. BURFIELD and RY, 1926, Pl. 4, Fig. 4; FOWLER, 1905, Figs. 34, 35, 1906, Pl. 2, Figs. (as *Sibogae*); RITTER-ZÁHONY, 1911c, Figs. 30, 31.
ata. Sufficient description above. BURFIELD and HARVEY, 1926, Pl. 6, ; Pl. 7, Fig. 41; BURFIELD, 1930, p. 214; RITTER-ZÁHONY, 1910a, Figs. 11—18; 1911c, Fig. 42.
leri. FOWLER, 1905 (as *hamata* var.); RITTER-ZÁHONY, 1909, 1911c, 3—45.
haloptera. GRASSI, 1883, Pl. 1, Fig. 1; RITTER-ZÁHONY, 1911c, Fig. 41.

Distribution	Species (Species in brackets occur only exceptionally).
Gulf of Bothnia	
Gulf of Finland	
Baltic proper	3, 4
Belt Sea	3, 4
Kattegat	3, 4
Skagerak	(1), 3, 4
Northern North Sea.	(1), 3, 4, 6, 7, (10)
Southern North Sea	3, 4
English Channel (eastern)	3, 4
English Channel (western)	3, 4, (7)
Bristol Channel and Irish Sea	3, 4, (7)
South and West Ireland and Atlantic	1, 2, 4, 5, 6, 7, 8, 9, 10, 12
Faeroe Shetland Area	1, (3), 4, 5, 6, 7, 8, 9, 10, 11
Faeroe Iceland Area	1, 4, 5, 6, 7, 9, 10, 11
Norwegian Sea	1, 4, 5, 6, 7, 9, 10
Barents Sea	1, 4, 10

References to Work on Biology

Numbers after references give species referred to

BIGELOW (1926, p. 308) 1, 2, 4, 7, 8, 10; FRASER (1937) 1, 3, 4, 7, 8, 10; HUNTSMAN (1919, p. 421) 1, 2, 4, 7, 8, 10; HUNTSMAN and REID (1922) 4; KRAMP (1918) 1, 4, 6, 10, 11; KÜNNE (1937) 3, 4; MEEK (1928) 3, 4; RUSSELL (1931, 32a, b, 33, 35, 36a, b) 3, 4; WIMPENNY (1937) 3, 4.

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— 1906. Siboga Exped. Monogr., XXI, Leiden.

GRASSI, B. 1883. Fauna u. Flora Golfes Neapel, Monogr. V.

HUNTSMAN, A. G. 1919. Canadian Fisheries Exped., 1914—15, p. 405.

— and REID, MARGARET E. 1922. Trans. Roy. Canadian Inst. Toronto, Vol. XIII, Pt. 2, p. 99.

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MEEK, ALEXANDER. 1928. Proc. Zool. Soc. London, No. 29, p. 743.

RITTER-ZÁHONY, R. VON. 1909. Exp. S.M.S. Pola in das östl. Mittelmeer. Denk. Ak. Wien, Bd. LXXXIV.

RITTER-ZÁHONY, R., 1909. Exp. S.M.S. Pola in das Rote Meer, Zool. Ergebn. Denk. Ak. Wien, Bd. LXXXIV.

— 1909. Zool. Anz. Leipzig, Bd. XXXIV, p. 787.

— 1910a. Fauna Arctica, Bd. V, p. 251.

— 1910b. Fisheries, Ireland, Sci. Invest., 1910, IV, p. 1.

— 1911a. Ergebn. Plankton-Exped. d. Humboldt-Stift., Bd. II, H, e.

— 1911b. Das Tierreich, Lief. 29, Berlin.

— 1911c. Deutsche Südpolar Exped. 1901—03, Bd. XIII, Zool. V., p. 1.

RUSSELL, F. S. 1931. Journ. Mar. Biol. Assoc., Vol. XVII, No. 2, p. 391.

— 1932a. Journ. Mar. Biol. Assoc., Vol. XVIII, No. 1, p. 131.

— 1932b. Journ. Mar. Biol. Assoc., Vol. XVIII, No. 1, p. 147.

— 1933. Journ. Mar. Biol. Assoc., Vol. XVIII, No. 2, pp. 555 and 559.

— 1935. Journ. Mar. Biol. Assoc., Vol. XX, No. 2, p. 309.

— 1936a. Journ. Mar. Biol. Assoc., Vol. XX, No. 3, p. 507.

— 1936b. Cons. Int. Explor. Mer., Rapp. Proc.-Verb., Vol. C.

WIMPENNY, R. S. 1937. Min. Agric. Fish., Fish. Invest., Ser. II, Vol. XV, No. 3 (1936) p. 16.

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BIANCO LUNO A/S, KBH.

1.

ɔmenclature and Units for the Indication of the Content of Constituents of Sea Water.

Report from the Sub-Committee

for the purpose of considering the chemical nomenclature to be used in the publications of the Council.

J. P. Jacobsen, K. Buch, B. Schulz and H. Wattenberg

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II. General View on Units 3
III. Expressions and Units for Common Use 4
IV. List of Symbols etc. of various Constituents of Sea Water and of the Units for the Indication of their Content 5

I. Introduction.

'he above-named Sub-Committee was appointed the Council in 1934. It has collaborated with ious scientists all over the world and presented reliminary report[1]) on its work in 1936.

n accordance with a resolution[2]) of the Council question of the chemical nomenclature and units be used in oceanography was proposed for con-ɛration at the General Assembly of l'Association céanographie Physique at Edinburgh in 1936. s Association accordingly recommended a scheme[3]) the nomenclature and the units to be used in mical oceanography and has further resolved to lertake the publication of instructions for con-ting the results from one unit to the other and ntually of tables for such conversions.

'he scheme adopted by the Association does not er to any material extent from that proposed in preliminary report of the Committee in 1936. ther this preliminary report was amended at the ncil Meeting in 1937[4]), in order to bring it more ely into accord with the scheme adopted by the ociation. Complete agreement on the manner of icating the content of constituents of sea water , however, not been obtained and some objections e been made to the establishment of an absolutely nite scheme. According to a resolution[5]) of the ncil the Committee set up for the purpose of sidering the chemical nomenclature and the units e used in the publications of the Council therefore ti ues in being for the purpose of deciding upon st ons that may be raised in this connection.

In the elaboration of the following scheme some designations are considered which have been introduced by committees existing in the various countries for the standardization of units to be used in science and technical work. This is for instance the case with the units val and Torr for one equivalent of an element or chemical compound and for the pressure of a column of mercury of the height 1 mm. at 0° at a locality where the acceleration is 980·665 $\frac{\text{cm.}}{\text{s}^2}$. The unit val is adopted as the standard unit in Germany and is proposed in Denmark. The unit Torr is adopted as the standard unit in Finland and Germany.

II. General View on Units.

A general view on units and designations principally comprising those upon which are based the following indications, is stated below. Several of the abbreviations for units which are given in brackets are used later in this report.

Mass Units.

1 ton (t.) or megagram (Mg.) = 10^3 kilograms (kg.) = 10^6 grams (g.).

1 gram (g.) = 10^3 milligrams (mg.) = 10^6 mygrams (μg.) = 10^9 nanograms (ng.).

One gram-atom of an element is defined by means of the atomic weight of the element. If the atomic weight is A, one gram-atom means A grams of the element. 1 gram-atom (g.-atom) = 10^3 milligram-atoms (mg.-atom) = 10^6 mygram-atoms (μg.-atom) = 10^9 nanogram-atoms (ng.-atom).

One equivalent of a substance is that amount of the substance which — according to the chemical processes in question — is equivalent to 1 g.-atom of hydrogen.

Rapp. et Proc.-Verb. du Conseil, Vol. C, 2ième partie, 90, 1936.
Rapp. et Proc.-Verb. du Conseil, Vol. C, 1ère partie, 33, 1936.
Proc.-Verb. de l'Association No. 2, page 58, 1937.
Rapp. et Proc.-Verb., Vol. CV, I, page 31, 1937.
ibid, page 31.

One equivalent (val) = 10^3 milliequivalents (millival).

The unit equivalent is used also for indicating an amount of several substances involved in the same way in a chemical process. One equivalent of a sum of the halogen-ions Cl′, Br′ and J′ is for instance that amount of the ions which — according to the processes:—

$$Cl' + Ag^{\cdot} \rightarrow Ag\ Cl$$
$$Br' + Ag^{\cdot} \rightarrow Ag\ Br$$
$$J' + Ag^{\cdot} \rightarrow Ag\ J$$
$$Ag + H^{\cdot} \rightarrow Ag^{\cdot} + H$$

is equivalent to 1 g.-atom of silver.

In such a case the ratios of the amounts of the different substances to one another are irrelevant and an indicated amount of equivalents has no relation to the mass of the substances in question but only to the mass of a single substance. According to the chemical processes given above this substance may be silver or hydrogen.

Ordinarily the halogen-ions in an amount of sea water are indicated as a mass of chlorine, found equivalent to an amount of silver, that again being equivalent to the halogen-ions.

One equivalent of base means an amount of one or more bases that — according to the process of neutralization — is equivalent to an amount of acid containing 1 g.-atom of dissociated or dissociable hydrogen.

One grammolecule of a chemical compound is defined by means of the molecule-number for the compound. If the molecule-number is M, 1 grammolecule means M grams of the compound.

1 grammolecule (mol) = 10^3 milligrammolecules (millimol).

The Temperature Scale.

The Celsius Scale is used with the Kelvin Scale as base. For temperatures between 0° and 100° this scale differs by less than 0·001° from the hydrogen thermometer scale.

Pressure Units.

As basic unit for pressure is used the "physical atmosphere" defined as the pressure of a 76 cm. high column of mercury of temperature 0° at a locality where the acceleration is 980·665 cm./s^2 (about 45° N. Lat.).

1 physical atmosphere (Atm.) = 760 Torr
= 1·0133 bar (b) = 1·0133 × 10^3 millibar (mb)
= 1·0133 × 10^6 dyn/cm.^{2}.

The unit bar quoted above is that principally used in meteorology. In physics and chemistry the pressure 1 dyn/cm.^{2} is commonly designated as 1 bar.

Volume Units.

The basic unit for volume is the true litre, i. e. the volume of 1 kg. distilled water at 4°.

1 kilolitre (kl.) = 10^3 litres (l.) = 10^6 millilitres (ml.).

Conditions to be stated when indicating the volume of an amount of gas.

The temperature and the pressure are to be stated.

The volume of an amount of gas is given preferably for the temperature 0° and for the pressure 1 Atm. These conditions are designated as "normal temperature and pressure" (NTP).

Special interest is attached to the volume at NTP of one grammolecule of a gas. This volume is designated as the molecular volume.

Conditions to be stated when indicating the volume of an amount of sea water.

A sample of sea water, arbitrarily chosen in the sea, may in several respects be characterized with sufficient accuracy by means of three variables, namely, the pressure, the temperature and the content of one or more of the major constituents.

The following considerations on sea water in this report are always applied to sea water that has been taken out of the sea and subjected to the pressure of the air only. The pressure may then be taken with a sufficient accuracy as constant and equal to 1 Atm. Salinity as defined by M. KNUDSEN[6]) has been chosen as representative for the content of one or more of the major constituents. The density and its derivates may then be taken as dependent on the temperature and the salinity only.

The volume of an amount of sea water depends upon its density and that in turn depends upon its temperature and salinity. Therefore an indication of a volume of sea water is to be followed by an indication of the density or by indications of the temperature and the salinity. On account of the fact that the salinity may be taken as a characteristic constant for a sea water sample under consideration the latter procedure is chosen; for a volume of sea water of known salinity, the temperature only is to be stated.

III. Expressions and Units for Common Use.

In the following section a list is presented of the symbols, expressions, units etc. that are to be commonly used in the indication of the content of the various constituents of sea water. The following remarks are made with regard to putting the list into effect.

---

[6]) See Hydrographical Tables edited by MARTIN KNUDSEN, Copenhagen 1901. That the salinity and not the chlorinity has been chosen as a characteristic of the sea water is in accordance with a resolution of the International Council for the Exploration of the Sea. (See Rapp. et Proc.-Verb., Vol. XCIV, page 33. Copenhague 1935).

All indications of the content of constituents of a water apply — in the absence of any other statement — to sea water without any suspended matter. The special indications of the hydrogen-ion concentration and the pressure of carbon dioxide in the r in equilibrium with the free carbon dioxide in the a water are inserted in the list but are disregarded the remarks below on the manner of indicating e units for the content of the constituents.

A constituent may be present in sea water as a ee dissolved substance or in combination with other bstances and (or) with electric charges of ions. ccording to the fact that the analytical method of termining the amount of a constituent in a given nount of sea water consists in the comparison of asses, the indication of the amount of a constituent plies to the amount of an element or to the mass a group of elements. This also holds good if the nount of a gaseous constituent is given in millires at NTP as the density of the gas at NTP is ways known.

The symbols etc. expressing the constituents are osen in such a way that in them a reference is ade to the element or to the group of elements used r indicating the amount of the constituents. If a nstituent is contained in more than one form in a water and the amounts of the constituent in its fferent forms are to be distinguished from one other, different expressions are used for the different rms of the constituent.

The following and their subdivisions are used as e commonly adopted units for the amounts of contituents:—

g. of a constituent
g.-atom of a relevant element
val of a constituent or of a sum of constituents
mol of a constituent
ml. of a gaseous constituent at NTP

The following are used as the commonly adopted its for amounts of sea water of known salinity:—

1 kg. of sea water
1 l. of sea water at 20°

The unit for the content of a constituent is desigted as a fraction, the numerator indicating a unit the amount of the constituent and the denominator nit for the amount of sea water. The substances d the conditions applying should in reality be ted in such a fraction. The unit for the content phosphate-phosphorus in sea water of known inity could for instance be written:—

$$\frac{\text{mg.-atom of phosphate-phosphorus}}{\text{l. of sea water at } 20°}$$

d the unit for the content of oxygen for instance:—

$$\frac{\text{ml. of oxygen at NTP}}{\text{l. of sea water at } 20°}$$

The substance to be stated in the numerator is given, however, by the symbol, or expression, for the constituent, and the substance to be stated in the denominator is always sea water. The indications of the substances in the units are therefore not inserted in the following list but are to be understood. The condition that a volume (ml.) of a gas is valid for the gas at NTP is stated in the relevant units. The expression "l. of sea water at 20°" is represented by the symbol L_{20}.

The units mentioned above as examples are therefore stated as follows:—

for the content of phosphate-phosphorus as: $\frac{\text{mg.-atom}}{L_{20}}$

and

for the content of oxygen as: $\frac{\text{ml. at NTP}}{L_{20}}$

In a case when g. is used as the unit for the amount of the constituent and kg. as the unit for the amount of sea water, the unit for the content of the constituent could have been written $\frac{\text{g.}}{\text{kg.}}$. In the following list this symbol is replaced by $^0/_{00}$.

It is to be remembered that the temperature 20° in the expression "l. of sea water at 20°" only serves as a definition of the amount of sea water. If the amount of a constituent varies with the temperature of the sea water — as for instance the free carbon-dioxide — the amount of the constituent is to be given for the relevant temperature of the sea water, which may be other than 20°.

In connection with the constituents mentioned in the following list some of the international atomic weights of 1937 and values for the molecular-volumes of the gases in question are given. The atomic weights and the values of the molecular-volumes for the gases are to be used by conversion computations.

IV. List of Symbols etc. of various Constituents of Sea Water and of the Units for the Indication of their Content.

Alternatives which may be employed if special usage or convenience makes it desirable are marked with an asterisk (*).

Chlorinity —
to be expressed as: Cl
Unit: $^0/_{00}$

The chlorinity means the amount of chlorine, indicated in grams, which — by means of "standard water" of standardized chlorinity — may be found as equivalent to the amount of the halogens, chlorine bromine and iodine contained as free or associated halogen-ions in 1 kg. of sea water.

The chlorinity may be determined — as has usually been done — by a volumetric titration with silver nitrate. If this method is used "KNUDSEN'S Hydrographical Tables" may be used for a direct computation of the chlorinity.

Atomic weight: Cl = 35·457.

Salinity —
to be expressed as: S
Unit: ‰

The salinity S is defined by the chlorinity Cl by means of the formula $S = 0{\cdot}030 + 1{\cdot}8050\ Cl$. Thus the salinity comprises the "oceanic salts" only and the formula is to be used only for chlorinities higher than 1 ‰.

Content of Sulphate —
to be expressed as: SO_4
Unit: ‰

The content of sulphate means the amount of SO_4, indicated in grams, contained as free or associated sulphate-ions in 1 kg. of sea water.

Atomic weights: S = 32·06, O = 16·000.

Content of Magnesium —
to be expressed as: Mg
Unit: ‰

The content of magnesium means the amount of magnesium, indicated in grams, contained as free or associated magnesium ions in 1 kg. of sea water.

Atomic weight: Mg = 24·32.

Content of Calcium —
to be expressed as: Ca
Unit: ‰

The content of calcium means the amount of calcium, indicated in grams, contained as free or associated calcium-ions in 1 kg. of sea water.

Atomic weight: Ca = 40·08.

Content of Free Oxygen —
to be expressed as: O_2
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$

The content of oxygen means the amount of oxygen, indicated in ml. at NTP, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: O = 16·000

Molecular volume of O_2 = 22·393 litre.

*Content of Free Oxygen —
to be expressed as: O_2
Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The content of oxygen means the amount of oxygen, indicated in mg.-atoms, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: O = 16·000

Molecular volume of O_2 = 22·393 litre.

Content of Free Nitrogen —
to be expressed as: N_2
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$

The content of free nitrogen means the amount of nitrogen, indicated in ml. at NTP, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: N = 14·008

Molecular volume of N_2 = 22·401 litre.

*Content of Free Nitrogen —
to be expressed as: N_2
Unit: $\frac{\text{mg.-atom at NTP}}{L_{20}}$

The content of free nitrogen means the amount of nitrogen, indicated in mg.-atoms, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: N = 14·008

Molecular volume of N_2 = 22·401 litre.

Content of Hydrogen Sulphide —
to be expressed as: H_2S
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$

The content of hydrogen sulphide means the amount of gaseous hydrogen sulphide, indicated in ml. at NTP, containing the same amount of sulphur as the free absorbed hydrogen sulphide and the free or associated ions of sulphides and bisulphides in an amount of sea water that at 20° has the volume 1 litre.

Atomic weights: H = 1·008, S = 32·06

Molecular volume of H_2S = 22·14 litre.

*Content of Hydrogen Sulphide —
to be expressed as: Sulphide-S
Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The content of hydrogen sulphide means the amount of sulphur, indicated in mg.-atoms, contained in the free absorbed hydrogen sulphide and in the free or associated ions of sulphides and bisulphides in an amount of sea water that at 20° has the volume 1 litre.

Atomic weights: H = 1·008, S = 32·06

Molecular volume of H_2S = 22·14 litre.

Total Content of Carbon Dioxide —
to be expressed as: Total content of CO_2
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$

The total content of carbon dioxide means the amount of gaseous carbon dioxide, indicated in ml. at NTP, containing the same amount of carbon as the free absorbed carbon dioxide and the free or associated ions of carbonates and bicarbonates in an

ount of sea water that at 20° has the volume itre.
Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

otal Content of Carbon Dioxide —
to be expressed as: Total Carbon-Dioxide-C
Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The total content of carbon dioxide means the ount of carbon, indicated in mg.-atoms, contained the free absorbed carbon dioxide and in the free associated ions of carbonates and bicarbonates in amount of sea water that at 20° has the volume itre.
Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

ntent of Free Carbon Dioxide —
to be expressed as: Free CO_2
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$

The content of free carbon dioxide means the ount of gaseous carbon dioxide, indicated in at NTP, that is equal to the total content of CO_2 above) minus the amount of gaseous carbon xide, indicated in ml. at NTP, containing the ne amount of carbon as the free or associated ions carbonates and bicarbonates in an amount of sea er that at 20° has the volume 1 litre.
Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

ntent of Free Carbon Dioxide —
to be expressed as: Free Carbon-Dioxide-C
Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The content of free carbon dioxide means the total bon-dioxide-C (see above) minus the amount of bon, indicated in mg.-atoms, contained in the free associated ions of carbonates and bicarbonates in amount of sea water that at 20° has the volume itre.
Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

essure of Carbon Dioxide —
to be expressed as: P_{CO_2}
Unit: 10^{-4} Atm.

The pressure of carbon dioxide means the partial ssure of carbon dioxide that must be present in o the pressure 1 Atm. being in contact with the water, when the exchange of carbon dioxide ween the air and the sea water is in equilibrium n equal temperature of the sea water and the air.

drogen-ion concentration —
to be expressed as: pH_t
Unit: See below.

The hydrogon-ion concentration of sea water at a temperature t is termed pH_t when the determination has been made on a basis of the conventional constants of S. P. L. Sørensen. For the activity of the hydrogen ions the designation paH_t may be used (see K. Buch: Ueber das Kohlensäuresystem im Meerwasser, Rapp. et Proc.-Verb., Vol. LXXIX, p. 20, and K. Buch: Die kolorimetrische Bestimmung der Wasserstoffionenkoncentration im Seewasser, Rapp. et Proc.-Verb., Vol. CIII, p. 27).

In publishing results it is to be stated if corrections are added for salt error and temperature effects and, if so, what corrections are used.

Excess base (titration alkalinity) —
to be expressed as: Alk
Unit: $\frac{\text{millival}}{L_{20}}$

Excess base or titration alkalinity means the amount of base, indicated in millival, that is equivalent to the surplus of the ions of bases in relation to the ions of strong acids — hydrohalic acids, sulphuric acid, nitric acid and the first dissociation step of phosphoric acid — contained in an amount of sea water that at 20° has the volume 1 litre.

For determination of the excess base the method of expelling the total amount of carbon dioxide of sea water by means of hydrochloric acid and titration of the surplus of acid by sodiumhydroxide with brom cresol purple as indicator may be used.

Content of Borate —
to be expressed as: Borate-B
Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The content of borate means the amount of boron, indicated in mg.-atoms, contained in free or associated borate-ions, in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: B = 10·82.

Content of Phosphate —
to be expressed as: Phosphate-P
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of phosphate means the amount of phosphorus, indicated in μg.-atoms, contained in free or associated phosphate-ions in an amount of sea water that at 20° has the volume 1 litre.

The proceeding in estimating the content of phosphate — including the correction, if any, for salt error — is to be stated in connection with the results.

Atomic weight: P = 31·02.

Content of Dissolved Organic Compounds of Phosphorus —
to be expressed as: Dissolved-Organic-P
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of dissolved organic compounds of phosphorus means the amount of phosphorus, indicated in μg.-atoms, contained as dissolved organic compounds of phosphorus in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: P = 31·02.

Remark: The amount of phosphorus, indicated in μg.-atoms, contained in the plankton in an amount of sea water that at 20° has the volume 1 litre is to be expressed as Plankton-P. The total amount of phosphorus, indicated in μg.-atoms, contained in an amount of sea water that at 20° has the volume 1 litre and has not been freed from plankton is to be expressed as: "Phosphate-P + Dissolved-organic-P + Plankton-P + Phosphorus contained in inanimate suspended matter of organic and inorganic origin (detritus)".

Content of Nitrate —
to be expressed as: Nitrate-N
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of nitrate means the amount of nitrogen, indicated in μg.-atoms, contained as free or associated nitrate-ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: N = 14·008.

Content of Nitrite —
to be expressed as: Nitrite-N
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of nitrite means the amount of nitrogen, indicated in μg.-atoms, contained as free or associated nitrite-ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: N = 14·008.

Content of Ammonia —
to be expressed as: Ammonia-N
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of ammonia means the amount of nitrogen, indicated in μg.-atoms, contained as free or associated ammonia in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: N = 14·008.

Content of Albuminoid Nitrogen —
to be expressed as: Albuminoid-N
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of albuminoid nitrogen means the amount of nitrogen, indicated in μg.-atoms, contained in the albuminoid compounds in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: N = 14·008.

Content of Organic Nitrogen —
to be expressed as: Organic-N
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of organic nitrogen means the amount of nitrogen, indicated in μg-atoms, contained in organic compounds in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: N = 14·008.

Content of Silicate —
to be expressed as: Silicate-Si
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of silicate means the amount of silicon, indicated in μg.-atoms, contained in free or associated silicate-ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: Si = 28·06.

Content of Arsenate —
to be expressed as: Arsenate-As
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of arsenate means the amount of arsenic, indicated in μg.-atoms, contained as free or associated arsenate ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: As = 74·91.

Content of Arsenite —
to be expressed as: Arsenite-As
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of arsenite means the amount of arsenic, indicated in μg.-atoms, contained as free or associated arsenite ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: As = 74·91.

Content of Iron —
to be expressed as: Fe
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of iron means the amount of iron, indicated in μg.-atoms, contained as free or associated ferro- and ferri-ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: Fe = 55·84.

Content of Manganese —
to be expressed as: Mn
Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of manganese means the amount of manganese, indicated in μg.-atoms, contained as free or associated mangano- and mangani-ions in an

ount of sea water that at 20° has the volume itre.
Atomic weight: Mn = 54·93.

ntent of Copper —
to be expressed as: Cu

Unit: $\frac{\mu g.\text{-atom}}{L_{20}}$

The content of copper means the amount of copper, icated in $\mu g.$-atoms, contained as free or associated cupri-ions in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: Cu = 63·57.

Content of radio-active substances. — The symbols etc. expressing the different radio-active substances are to be chosen in accordance with the common usage in physics. As unit is to be used $^0/_{00}$, i.e. grams of the radio-active substance per kilogram of sea water.

2.

Fluctuations in the Herrings of the East Anglian Autumn Fishery, the Yield of the Ostend Spent Herring Fishery, and the Haddock of the North Sea — in the Light of relevant Wind Conditions.

By

J. N. Carruthers.

(Fisheries Laboratory, Lowestoft).

Herring.

The last issue of the Rapp. et Proc.-Verb. (Vol. CV, III, 1937) contained a short paper by Carruthers and Hodgson under the title: "Similar Fluctuations in the Herrings of the East Anglian Autumn Fishery and certain Physical Conditions". In it appeared a graph which showed the two following quantities plotted against each other:— the percentage of 3-year-old herrings in the catches from year to year, and the atmospheric pressure gradients controlling run of wind up the Southern Bight from the Straits of Dover during the spawning seasons concerned. Six successive year-classes of herrings were seen to have risen or fallen in strength from their immediate predecessors, in the same sense as the pressure gradients.

In other words, there was a parallelism for all the years embraced (the year-classes 1926 to 1932) when the herring fluctuations were plotted against pressure gradient.

It was desired to extend the comparison backwards in time to cover the year-classes of 1923, 1924 and 1925, but the requisite pressure data were not then available although the values for herring were.

The pressure graph has now been extended to embrace all spawning periods from that of 1923/1924 up to that of 1937/1938, and Dr. Hodgson has kindly furnished me with a value for the percentage of 3-year-old herrings in the catches of the 1936 autumn fishery.

It has consequently become possible to extend the comparison so as to cover eleven year-classes of herring. This is an extension of four steps, and the appropriate graph appears below as Fig. 1. It is seen that there is a parallelism over all ten steps, and it would seem that the spawning products in any year experience better or worse survival conditions than did those of a year earlier, according as they can be supposed to have been spread further or less far away from the neighbourhood of the Straits of Dover. It should be noted that the pressure data refer only to the months of December and January, and, concerning the obvious lack of proportionality between the two sets of data which express the fluctuations compared, the remarks made in the paper of a year ago and repeated and amplified below, should be borne in mind.

For a reason which will appear later, indications of the percentage occurrence of 3-year-old herrings in the catches of autumns 1923, 1924, and 1925 are also given in the graph — but without pressure data. This is because Dr. Hodgson regards the three herring values concerned with less confidence than attaches to his later estimates.

At the end of the paper by Carruthers and Hodgson earlier referred to, attention was paid to the yield of the Ostend fishery for spent herrings over the seasons 1927/1928 to 1935/1936.

Figures for yield were set down and inspected side by side with the pressure graph to which the fluctuations of the herrings of the East Anglian Autumn Fishery had been compared. It was seen that an inverse parallelism displayed itself for all the eight yearly steps. If the fishery had been more productive in one year than in the year before, the pressure gradient for "from-Channel" winds had been less and *vice-versa*.

In Fig. 1 I have plotted the Ostend fishery figures and, for clearness, have done so by reference to an inverted scale. An additional figure — that for season 1936/1937 has recently been communicated by Professor Gilson, and has been included. The inverse parallelism is brought out very clearly.

It seems reasonable to argue along these lines:— as from year to year, increased "from-Channel" air flow means increased "from-Channel" water flow, and this in turn means:—

(1) that the passively drifting spawning products will be distributed further afield — apparently a good survival augury for the herring, and
(2) that lately-spawned herrings in such an enfeebled condition that they drift with the water movements more or less, will be more quickly swept along the Belgian coast and will therefore remain subject to capture by the Ostend fleet for a shorter time, the converse would also hold.

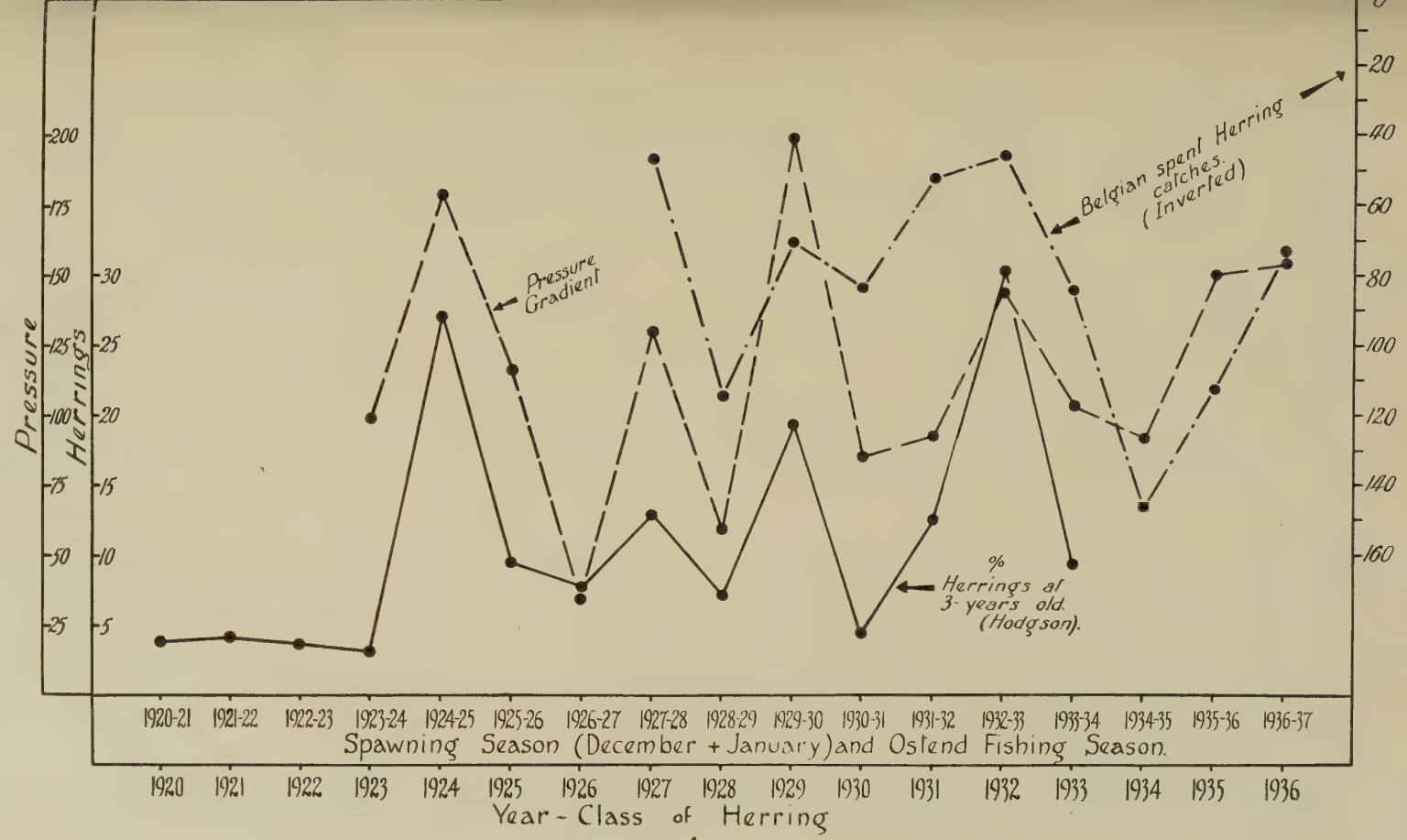

Fig. 1.

Fig. 1. Graphical Comparison of the Yearly Fluctuations in the Herrings of the East Anglian Autumn Fishery and in the yield of the Belgian Spent Herring Fishery with those in Atmospheric Pressure Gradient controlling run of Wind northwards up the Southern Bight during December and January.

[Key to Fig. 1. Of the two scales on the left, the right-hand one measures percentage occurrence of herrings at three years old in the East Anglian catches, and the left-hand one measures atmospheric pressure gradient as explained in "Note One" in the Appendix. The inverted scale on the right refers to the yield of the Belgian Spent Herring Fishery; values read × 100 give in kilograms, GILSON's "Mean Weight of a Day's Capture".]

In such comparisons as that here made between fluctuations in herring year-class strength and pressure gradient, the presence of parallelism without proportionality calls for some comment. Does the absence of proportionality imply that the parallelism is of but little interest — that it has no real meaning? It could not justifiably be argued that such is the case unless it were at least known that:—

(1) The fish censuses were as completely reliable as a properly conducted human census.
(2) The response of water to wind is always more or less the same in the area concerned.
(3) Equal values of the pressure gradient data employed necessarily mean the same thing in terms of wind, and unequal values cannot mean the same thing.

Regarding point (1) no comment is offered. Concerning point (2), we need only point to the facts that the North Sea is not a lake and that its waters are subject to urges of Atlantic incidence. As to point (3), isopleth diagrams would surely show that a given pressure difference could exist between the two sides of the Southern Bight on different occasions, without the intervening isobar picture being exactly the same.

In view of what has been said, it seems very reasonable to seek no numerical correlation, and to contend that, such parallelism as we have displayed being all that can be hoped for, when it exists it should be regarded as being of importance. Its importance will be measured by the length of the term of years for which it holds good.

What has just been said regarding the lack of need for concern over absence of proportionality, applies with even greater force to the case of the haddock, because a much wider area of sea is involved.

Haddock.

If it were possible to display any similar kind of parallelism in the case of the haddock, it could perhaps be invested with more importance than attaches to the case of the herring. This seems reasonable on the grounds that any such parallelism would necessarily have displayed itself in spite of the fact that there must be much greater likelihood of smoothing out in view of the considerations just raised as items (1), (2), and (3), above.

In an earlier paper[1]) I found some reason to suppose that it augured well for the survival of a haddock brood if, at spawning time, the waters in the spawning area were urged to the southwards. That supposition was, however, the outcome of an indirect approach to the problem. The recent appearance of a paper by Dr. Raitt on "Stock Replenishment and Fishing Intensity in the Haddock of the North Sea"[2]), has made it possible to approach the subject of haddock fluctuations provided with a very convenient summary of the relevant facts concerning the fish; a graph from Raitt's paper is here reproduced.

It is nothing new to draw attention to the fact that to a noteworthy degree, the haddock and herring fluctuate inversely — that good years for haddock have been poor years for herring and *vice versa*. The writer discussed this matter in some detail in his paper already referred to (1935). On consulting the herring graph in Fig. 1, and the haddock curve in Fig. 2, the comparison can be very easily made for ten steps and it is noted that:—

The fluctuations in strength have been notably opposite in sense six times, and have been definitely in the same sense twice. Of the two remaining steps, the trends of the curves were also opposite in the case of 1925 to 1926 but the slope for one fish (herring) was slight; they were in the same sense in the other case (1924 to 1925) where the slope for haddock was slight.

The "oppositeness" in strength for some of the well-known peak years is very pronounced.

There is another point well worthy of comment here, and it is one to which the writer does not remember attention having been previously drawn.

It is suggested that the reader imagine the haddock curve of Fig. 2 which portrays Raitt's data, superposed upon the herring curve of Fig. 1 which portrays Hodgson's data — and the haddock curve then shifted one step to the right. This means that the ordinate for haddock born in 1922 is pictured as lying upon that for herring born in winter 1923/24, and so on. The similarity of the two curves is now very striking. Ten steps or year-to-year slopes can be compared, and it is seen that, only in the case of the small fall for haddock from 1929 to 1930, do the two curves move in opposite sense. Moreover, there is agreement for the three slopes pre-dating pressure data — though, as earlier remarked, Dr. Hodgson is not able to be so precise about his earliest herring figures as about his later estimates.

This agreement, almost total for thirteen yearly steps, certainly seems to warrant the description "striking", and one is led to wonder whether there may not be some explanation which makes sense. Can any linkage be thought of which can account for the fact that the ups and downs of haddock fluctuations have been so strikingly reproduced by herrings born $1^1/_2$ years later? The experts are of the opinion that "nothing disastrous happens to a haddock brood after they leave the pelagic stage and take to bottom habitat — *i.e.*, at about 6 months' old".

Before commenting on the similarities of the three curves of Fig. 2, it will be well to remark that we had good reason to suppose that the cause of fluctuations in year-class strength of North Sea haddock (and cod) should be sought *within* the North Sea.

[1]) "Certain Fishery Applications of the Results of Researches on Marine Currents carried out from the Lowestoft Fisheries Laboratory". Appendix to the Ministry's series of Fishery Investigations, Ser. II, Vol. XIV, No. 4, London, 1935.

[2]) In the Council's Journal, Vol. XI, No. 2, pp. 211 *et seq.*, Copenhagen, 1936.

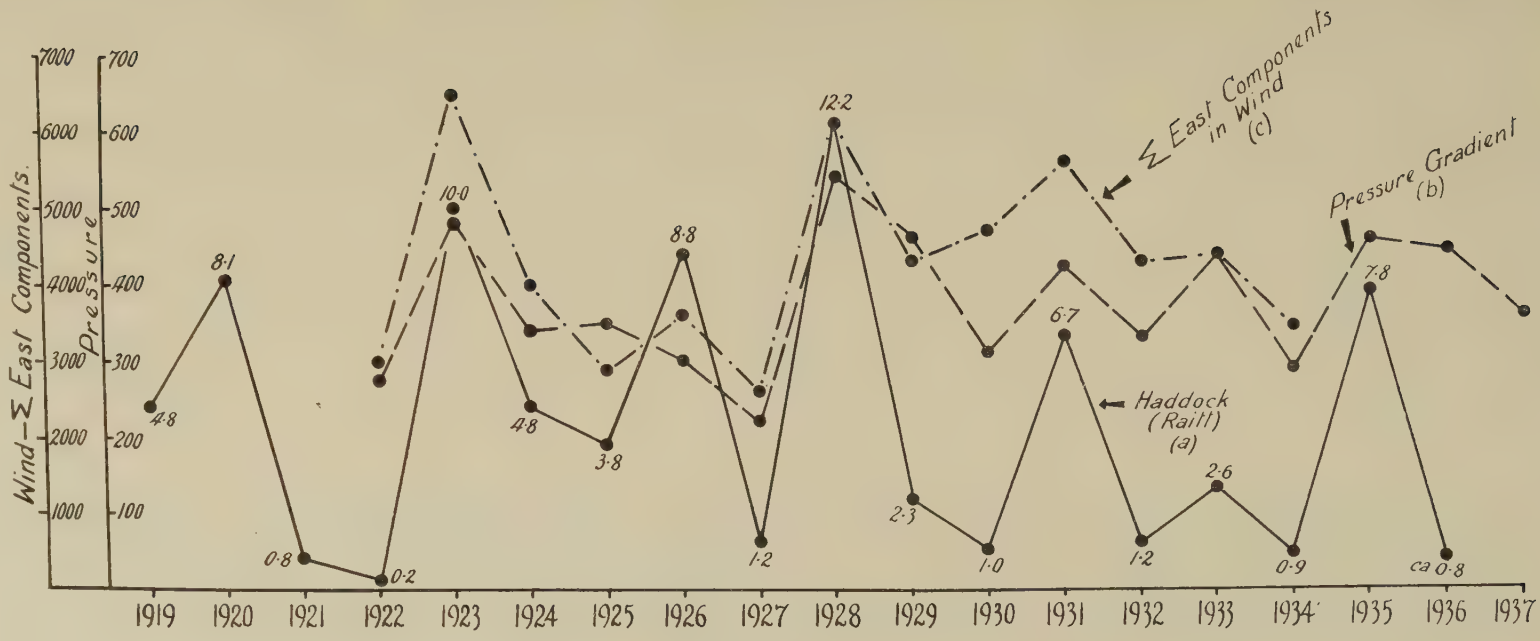

Fig. 2.

Fig. 2. Showing (a) RAITT's curve giving the "Relative Numerical Values of North Sea Haddock Broods in the First Year of Life, 1919—1934", (b) a curve portraying Pressure Gradient Values implying Wind from the SE. Quadrant during March, April and May, and (c) a curve relating to "East in the Wind" as computed from actual observations during February, March, April and May, at three appropriate Stations.

[Notes re Fig. 2. (1) For details as to curves (b) and (c) see Notes Two and Three respectively in the Appendix. (2) The 1935 and 1936 haddock values in curve (a) were kindly communicated by letter from Dr. RAITT and are to be regarded as subject to re-consideration by him.]

This impression arose some years ago as the result of certain findings concerning the two peak years for haddock, 1923 and 1928. In respect of that area of the North Sea to which interest attaches in the present connexion, it was found that the springs of those two years were very similar in certain meteorological characteristics. Also, the two respectively preceding years 1922 and 1927, alike poor years for haddock, could easily be "brought into line" meteorologically and shown to contrast with 1923 and 1928 in respect of more or less local wind conditions reigning in spring.

It only needed the belief that the influence of wind on water *could* be great enough to rule fluctuations in year-class strength, to direct detailed attention to the problem.

As the result of remarks made in my 1935 paper on the subject of cod and contemporaneous meteorological fluctuations, I was fortunate enough to receive correspondence from a high meteorological authority. Sir GILBERT WALKER, C.S.I., F.R.S., formerly Director-General of Indian Observatories and lately Professor of Meteorology in the Imperial College, displayed interest in the subject of fish fluctuations, and asked to see relevant literature. He tabulated data from 1875 onwards "of the North Atlantic Oscillation .... positive figures for which mean strong ocean winds towards northwest Europe .... with warmth there and cold in Labrador; and *vice versa*". He worked out data for March to May, June to August, September to November, December to February, and for whole years. On comparing his data with those of fish fluctuations supplied to him, he declared himself unable to see any relationship at all — rather to his surprise. The springs of 1923 and 1926 (good for haddock) were normal, but 1928 was in marked contrast and negative. He said "clearly it means, as might be expected, that it is the weather in the North Sea that matters, rather than that of the North Atlantic when the latter is not identical with it". He was, therefore, of the opinion that the right procedure in the case of the North Sea haddock and cod, was to continue seeking explanations within the North Sea.

For the months of March, April and May of the years 1922 to 1937 (and in some cases of 1919, 1920 and 1921 as well) atmospheric pressure data in the form of monthly means were procured for a number of stations judged to be suitable for the consideration of implied winds from most directions over the haddock area. Dr. C. E. P. BROOKS kindly supplied data for Deerness, Spurn, Utsire and Blaavands Huk, and thanks are offered also to Dr. SVERRE PETTERSSEN and Mr. LOMHOLT for additional data relating to Norway and Jutland respectively.

With two stations on the British side of the North Sea (more if consultation of Meteorological Office publications were undertaken) and six on the eastern side, many pressure gradients could be investigated. The data related to three separate months, and it was not known which was the best line to follow — whether to pay attention to all three, or to April and May, or to May alone. Very many trials had to be made until it became clear that the best parallelism would result if the haddock curve were compared with a curve portraying pressure gradient for wind between south and east. Eventually, out of some dozens of curves, that representing an average of the gradients: Utsire to Spurn, and Blaavands Huk to Spurn was chosen for publication. To magnify the ups and downs of this pressure curve, a step explained in "Note Two" of the Appendix was taken.

In view of the degree of resemblance between the two curves, it was decided to plot also against the haddock, certain wind data of a very comprehensive nature originally prepared for another purpose. The nature of these wind data is described in "Note Three" in the Appendix, and it is to be remarked that they would probably have been better for our present purpose if February had not been included.

Concerning both pressure and wind, it needs to be stated that we do not know whether we have dealt with the "best" months. This being so, it is to be realised that a much better parallelism than we show, *might* be forthcoming on longer investigation.

Haddock Fluctuations Compared with Fluctuations in (1) Implied Wind from the SE. Quadrant, and (2) "East in the Wind".

Reference to Fig. 2 shows that it is possible to compare the pressure and haddock curves over fourteen steps, and reveals that in twelve cases the two curves move up and down together. In one case (1925 to 1926) there is clear disagreement, and it may be remarked in passing that the 1925 to 1926 haddock change hardly ever agreed with the 1925 to 1926 pressure change in the many trial curves constructed.

The remaining step where disagreement occurs is that of 1924 to 1925, and this is of little importance because the haddock change was small and the pressure change almost nothing.

When we turn to what for brevity we have called "east in the wind", comparison is possible over twelve yearly steps and agreement is present in all but one case — that of the step 1929 to 1930.

In this latter case the wind curve does not rise a great deal and the haddock curve does not fall very steeply.

Cod and Pressure Gradient.

No particular attention has been paid to the cod in the course of this study, but the following series of figures relating to the pressure gradient Fanø to Skudesneshavn for the months of March, April and May is of some interest.

1922	*1923*	*1924*	*1925*	*1926*
+ 6·9	— 1·0	+ 5·2	+ 2·4	+ 2·7
1927	*1928*	*1929*	*1930*	*1931*
+ 2·0	— 2·9	+ 1·9	— 3·0	— 3·4

es set down are measures of wind from a direction
of west where positive; negative values imply
are a measure of wind from north of east on the
rn side of the North Sea.
paper by GRAHAM published in the Ministry's
ry Investigations in 1934, gives figures for
ive brood-strength for the year-classes 1922 to
, and an indication for 1931 has since been
lied to the writer. They are as follows:—

1922	*1923*	*1924*	*1925*	*1926*
2	7	6	6	1
1927	*1928*	*1929*	*1930*	*1931*
3	8	2	7	7++

Comparison is possible for nine steps and it is seen that in all cases but one the cod figures rise with increase of implied wind from north of east, and fall with increase of wind from south of west. The disagreement occurs with the pressure step 1924 to 1925, where a fall in pressure goes with no change in cod, but it is hardly likely that the cod figures 6 and 6 can be taken to denote precise equality. Since this pressure series was not obtained in the course of a search specially devoted to the cod, it is quite possible that further investigation would result in the discovery of a much better parallelism.

In conclusion, the reader to whom the subject matter of this paper is of interest, is enjoined to bear in mind the remarks made concerning the absence of proportionality between the sets of data expressing the fluctuations compared.

APPENDIX

One.

tting each of the places Brussels, Kew, Helder Yarmouth be denoted by its initial letter, and g the suffixes d and j denote the mean atmoic pressures for December and January respecy, the quantity plotted in Fig. 1 was:—

$$+ B_j + H_d + H_j) \text{ minus } (Y_d + Y_j + K_d + K_j) \ldots + 100$$

ressures having been expressed in tenth-millibars he number 100 added to avoid the inconvenience egative values.

Two.

tting B stand for Blaavands Huk, U for Utsire, S for Spurn, and letting the suffixes m, a, and tand for March, April, and May respectively, the tity plotted in the pressure graph of Fig. 2 was:—

$$(B_m + B_a + B_{ma} + U_m + U_a + U_{ma}) \text{ minus } (S_m + S_a + S_{ma})$$

of the nine values being the mean atmospheric ure (expressed in tenth-millibars) at the place for the month indicated.

This "gradient" has no real meaning in terms of implied wind such as it would have had if twice the quantity subtracted had been taken away (then it would have represented the sum of two gradients = twice the average) but the quantity indicated was plotted in order to magnify the ups and downs somewhat.

Note Three.

From the Daily Weather Report (British Section) of the Meteorological Office, the observations of wind strength and direction at Spurn, Tynemouth and Inchkeith (four observations daily) were collected into the sixteen main divisions of the compass after converting from Beaufort numbers into miles per hour. The months February + March + April + May were taken into account. At this stage values had been obtained which, if multiplied by 6, would represent the "miles of wind" from the various directions during the entire period of four months. For each year, from 1410 to 1450 observations were dealt with. Amongst other steps next taken, a summation was made of all cardinal components for each year, and the quantity plotted represents the result of resolving all the entries having east in them along the east line and adding the components so obtained. The resulting values ranged from 6,473 for 1923 and 6,094 for 1928, down to 2,602 for 1927.

3.

Continuous Current Measuring from Lightvessels.

Review of Progress, with Results for a third Winter — 1937/38.

By

J. N. Carruthers.
(Fisheries Laboratory, Lowestoft).

In Volume C of this series which appeared in 1936, I published a short paper entitled "Continuous Current Measuring in the Southern Bight", and the issue of last year (Volume CV) contained a second paper under the title "Continuous Current Observations for Fishery Research Application". Both those papers were written in the hope that programmes of non-stop current measuring would be undertaken from more lightships in the southern North Sea. It is believed that continuous observations providing information upon water-flow under all conditions of weather and in no matter how silty water, are essential in fishery research. A very simple and robust apparatus designed to do what was needed, and which had been in use long enough to justify claims that it really could do so, was described. Sample results were presented.

It is now known that the instrument in question can (as was expected) run for very long periods with only the most negligible upkeep costs, and it seems desirable to state where it is at present in use.

The Vertical Log has recently been installed on five more lightships for continuous use throughout the year, and has been used during an entire winter from yet another one. In view of this considerable increase in the number of observing points, it is thought that workers in various branches of marine research may be interested to learn what data are available at the present time.

The instrument is, thanks to the kind permission of Trinity House, kept in continuous commission aboard the following English lightships: Cromer Knoll, Varne, and Royal Sovereign. That aboard the Varne lightvessel was installed early in March 1938 in substitution for the Drift Indicator which had been in use there for nearly twelve years. The change-over became necessary owing to the pending replacement of the wooden lightship by a large steel vessel. During the last three winters, Vertical Logs have been in continuous use from the Galloper and Sandettié lightvessels. In the case of the last-named, the Lowestoft Laboratory again acknowledges kind co-operation on the part of the Office Scientifique et Technique des Pêches Maritimes. During this last winter (1937/38) one of the instruments has been kept in continuous commission aboard the Horns Rev lightvessel. In this case the work was under the control of Dr. Täning.

All the instruments supplied by the Lowestoft Laboratory to carry out observations on its behalf differ very little from what was shown in the two illustrations contained in the paper of a year ago. The few changes which have since been made in no way constitute any departure from simplicity — rather the reverse in fact. They will be mentioned below, and it is to be added that the apparatus has now taken on its final form, no further modification whatsoever being contemplated.

A matter which calls for attention here is the very welcome extension of the work which has taken place in a rather unexpected quarter.

The Vertical Log has now been adopted by the Rijkswaterstaat for use from Dutch lightvessels[1]), and although their observations were not undertaken for fishery research purposes the results are no less useful in the latter connexion than if they had been. For their purposes the Dutch engineers have made

[1]) See J. van Veen, "Die Anwendung von Carruthers' 'Vertical Log' Strommesser an Bord der niederländischen Feuerschiffe" — in Ann. d. Hydrogr. usw., LXVI Jahrg. (1938), Heft 1, p. 52.

See also a letter from Dr. van Veen to the Editor of the Journ. du Conseil on the subject of Current Measurements from Dutch Lightships. This appeared on page 335 of the December 1937 issue of that publication (Vol. XII, No. 3).

n alterations and do not use a separate unit ewing direction. It is necessary to speak of these n observations in some detail and to describe ıpparatus as the Rijkswaterstaat use it. The s where they use it should be stated and the e of the very comprehensive graphs of results ı they prepare should be made known. With mple facilities at his disposal, the Chief Engineer e Rijkswaterstaat (Dr. J. VAN VEEN) has carried alibrations of the Vertical Log which greatly ıse its utility; this will be referred to below.

e instrument has been in continuous use aboard Iaas lightship since July 1937, and the writer nformed in early February that similar obser- ns would be instituted from the Noord-Hinder Haaks lightvessels in that month (February , and from the Terschellingerbank some weeks Thanks to the kindness of Dr. VAN VEEN it is ole to reproduce here a portion of one of the s upon which the Dutch data on water-flow lightships are entered. The graph in question hes over half a year and presents an unbroken d of wind, of vertical tide, of total run of Flood Ebb, and of overall set. That such graphs are ll be available for four lightships, can hardly o be a matter of interest to workers in several of marine research. Dr. VAN VEEN has also hed the writer with simple statements as to ıal flow averaged for whole months.

Dutch Practice.

om Netherlands lightvessels a somewhat modified of the apparatus is used. The spindle below ı the cup system hangs has been housed in gim- and direction is taken by noting the position ubble which moves away from centre in accor- with the lead-away of the cups themselves. nethod of direction viewing adopted is more or hat familiar to users of Jacobsen's Libelle meter. ıd of the rope suspension figured in my last s paper a chain suspension is employed. For n reasons noted below a chain suspension is ıised also by the Lowestoft Laboratory, but (so spondence shows) it is of greater strength than used by the Rijkswaterstaat.

ow the cups, the Dutch do not hang a heavy terminating in a propeller (of opposite sense to ups) as is the practice of the Lowestoft Labora- They have supplied weight in the form of a . plummet which is joined on to the bottom e cups by means of an elaborate swivel. The met is pear-shaped and is of course attached its hemispherical end upwards. The use of this weight is advised to obtain good results in g currents, and arrangements have recently been to experiment with such a plummet aboard nglish lightvessel. If it could be used considerable my would be achieved, but experience alone how whether it can be adopted in place of the manhandled chain aboard lightvessels which are not provided with a specially designed and convenient davit such as the Dutch lightships have.

Dutch practice is to note the revolutions each half-hour during day and night on one counter only. The "number of revolutions per minute" being known, an accurate velocity is read off from a calibration curve. To the velocity so obtained a precise direction is assigned by noting the position of the bubble. The calibration curve in question was prepared by comparing the showing of the Vertical Log against the indications of Ott precision instruments of electrically recording type. Dr. VAN VEEN has made this curve available to all users of the instrument — a copy of it appearing in each of his two short papers earlier referred to. Such a calibration curve could be prepared only from observations made on shipboard. This is so because the Vertical Log could not be towed through still water in an experimental testing tank. The present writer had never been able to do more than compare the showings of a Vertical Log with the results from frequent runs of a deep-riding float. The latter had been done on several occasions for all stream speeds up to almost $3^1/_2$ knots, and in the course of the original tests, experiments were made with various weights beneath the cups. With the rig finally adopted (heavy chain and opposing propeller beneath the cups) it was found that up to the speed mentioned, revolutions put on could be converted into sea miles by dividing by 300. Examination of Dr. VAN VEEN's calibration curve shows it to be very nearly a straight line, and reveals that if it be taken as such, a general conversion factor exactly equal to that arrived at by the present writer ($\div$ 300) is obtainable from it.

In the case of the Dutch observations, the underwater part of the Vertical Log is submerged to such a depth that the mid-point of the cups is 10 metres below surface.

The portion of a graph relating to continuous observations made aboard the Maas lightship is here reproduced with Dr. VAN VEEN's kind permission.

English Practice.

The following remarks apply to the observations carried out aboard the Cromer Knoll, Galloper, Sandettié, Varne, Royal Sovereign, and Horns Rev lightvessels — the observations aboard the French and Danish ships having been made in keeping with requests from Lowestoft.

The apparatus used was and is nearly the same as figured in the two illustrations which appeared in my last year's paper. The writer much prefers to continue using the separate cheap and "home-made" unit for the viewing of direction. Much cost is thereby saved and there are other attractions which need not be gone into in detail here. It continues to be our practice to use eight small revolution counters, each one of which takes account of water movements towards one particular compass octant. The way in which the observations are carried out has been described

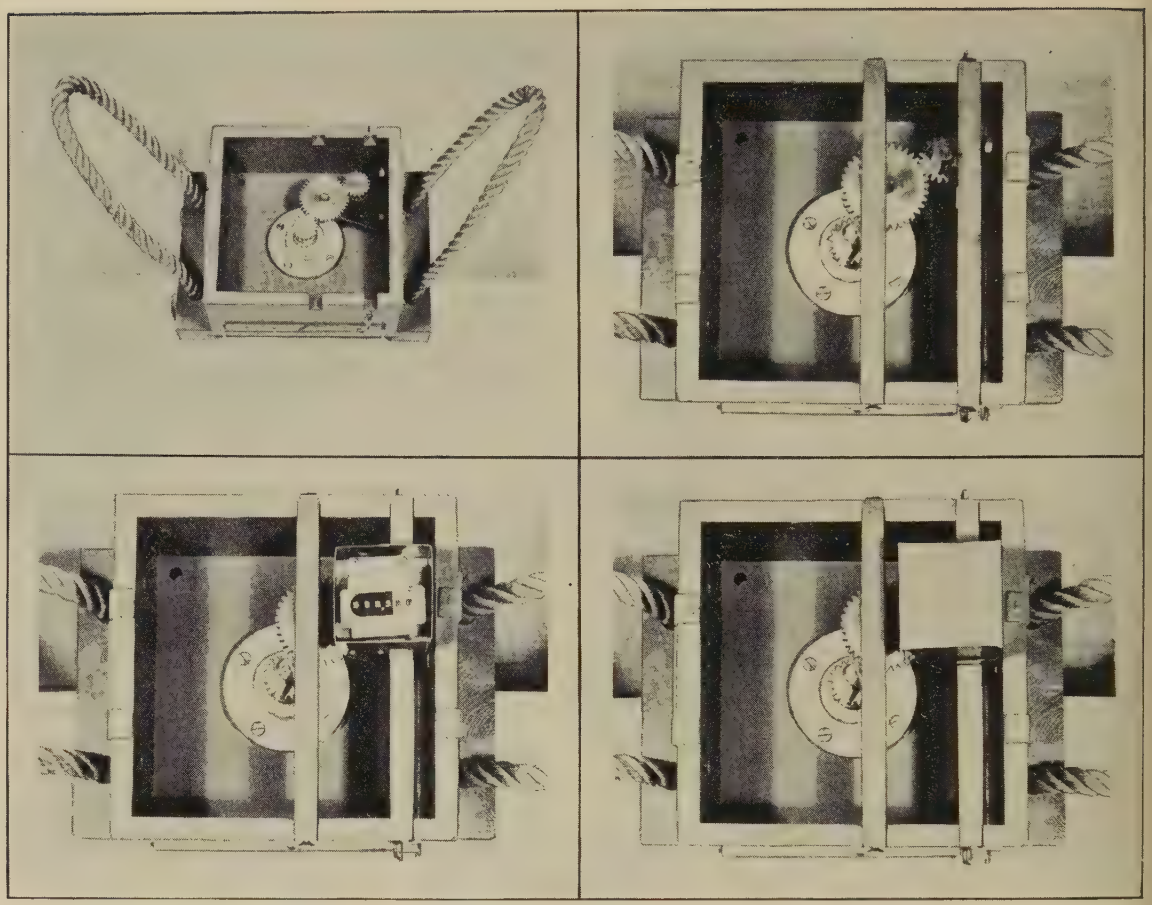

Fig. 2. Showing the Registering Parts of the Vertical Log Current Meter.

in earlier papers, and the use of the hand-set wooden "compass" has been found to be very convenient and suitable. The observer has not the least difficulty in deciding which of the eight small counters (each one bears an identification number) has to be in registration at any time. The wooden "compass" is very easily kept set by reference to objects whose bearing is known, and if desired it is just as easy to read off without hesitation a precise direction of stream as it is to decide within which octant the stream direction falls. On some lightvessels it is necessary to refer to the ship's compass only during foggy weather, marks of known bearing being available most of the time.

If a better "grip" on the water is desired than that afforded by the light hanging chain employed with the direction unit, rope "tassels" can easily be secured in the links. The very nature of the simple device employed to view direction means that wild plungings of the vessel have the minimum effect in masking the direction of the stream. The pointer on the inboard wheel remains very steady because there is so much scope for the damping out of the movements due to the plunging of the ship in heavy weather. It should also be remarked that the direction of stream can be very easily read off no matter how the ship is held "off tide" by wind. The pointer can swing right round to point straight inboard if the stream sets under the ship.

As regards the main part of the instrument (that figured last year as the "measuring unit") we may now note the few changes — chiefly by reference to Fig. 2.

The rope-handled box in which the registering part of the instrument is housed, has been altered in a way which makes for extra strength, and which permits easy renewal of the rope handles by anyone who has not the time to make the most seamanlike kind of knot. The box is now carried upon a strong "swing seat" made of thick hardwood, and all that is necessary when renewing the ropes is to make simple overhand knots beneath. The holes in the sides of the box through which the rope handles were previously passed are now conveniently used for the

chment of a preventer rope, and the new position he rope handles gives more clearance for easy ition to a new fitment. By means of the simple of cogs shown in the photograph, it has been ible to provide a small wheel turning in time the big vertical spindle. Thanks to this arrange- t we are now able to have a really satisfactory ter Counter. A second pair of cuts has been made ne box to take one of the standard wooden slats, upon this a small counter has been mounted y from the middle to engage with a vertical pin ed by the outer of the two small wheels. Since latter rotates in time with the main spindle we get duplicate registration. The idea is that the -middle" small counter can be used to register he revolutions made. Then, if one of the eight l counters (which are changed by hand as the m direction changes from one octant to another) to function properly, the reading it should have n can be obtained in an obvious way. It is very enient to have a small counter mounted specially ct as a Master (see the top right-hand part of llustration) because the spares which the observers can be drawn upon for renewal in case of need. , the use of such a small counter could be reverted n the unlikely event of trouble arising with the satisfactory Master Counter which is shown in bottom left-hand part of Fig. 2. This, which is standard in the instrument as used aboard lish lightships, has been in use for several months great success. A large six-figure counter with t reading was obtained from the makers of a known gas-meter. The working parts of it are h bigger and therefore much less liable to give ble than are those of the small counters. It was nted on a square of oak down through a hole ne centre of which its spindle passes, and brass were then fitted so that the counter was enclosed box. Melted vaseline was then poured into the to about half-depth. After this had solidified, rless medicinal paraffin was poured in so that counter was covered with oil of the kind shown xperiment to be the best for the purpose.

is Master Counter works all the time in an oil , and when in use it is covered over by a card- d half-box previously soaked in molten paraffin and well greased inside and out. In recent months s been found possible to make good the readings ny small counter which had worked badly, and se no records where it had become necessary to ce one of the small counters. Using an instrument l with the reliable big Master Counter here ed, it is possible to work in our routine fashion rnation of eight or less counters to get the total r movements within the various compass octants erned) and yet at the same time have another rver working as do the Dutch. The two ways of rving can be in progress at the same time with- nterference the one with the other. The large er Counter in its oil bath can be removed at for accurate reading.

Apart from this change there remains only the substitution of chain ($^3/_8$ inch) for rope suspension to be noted.

As stated above, it is intended later to try using a heavy plummet as the only weight beneath the cups. Should this prove practicable, all that would really need to be bought from the makers by anyone desiring to possess the instrument, would be the set of cups and the heavy ball-bearing spindle from which the submerged portion of the instrument hangs. If the counters were bought independently, nearly everything else could be made in the laboratory. The cogs could be obtained from almost any engineer, and the plummet (the dimensions of which would be supplied on request) could be ordered from any foundry. An instrument as bought from the makers in England, would comprise what was shown as "the measuring unit" in the writer's paper of last year. With it would go ten small counters. The making of the direction-viewing unit and the fitting of a Master Counter if desired, would need to be arranged for by the purchaser.

It should be mentioned that there was a good reason for substituting a chain suspension for the rope one.

It was done to ensure that if any vessel came alongside the lightship without time being given to haul the instrument inboard, the boom and box could be got inside the rail and the chain left hanging over it. Any chafing would not matter with the chain whereas the rope in such circumstances might have been rubbed through.

Results Obtained.

An inexcusable error was made when stating the results from the Galloper lightvessel in the paper of a year ago (Rapp. et Proc.-Verb., Vol. CV., 1937, App. 6 to Part III — p. 24). The information for January 1937 and Winter 1936/37 was wrongly given; the residual currents for these two periods were respectively:—

3·9 miles a day towards S. 28° W.
and
2·6 miles a day towards S. 34° W.

The results from various lightships for winter 1937/38 are of particular interest and are given below. They are seen to show the existence of conditions very different from those of the two preceding winters, and it may be possible to make some use of the (now published) data relating to the last three winters when, some years hence, the outcome of the local fish spawnings is known. In all cases it is the mean residual current in miles per lunar day towards a true direction which is given, and the observations refer to the depth of $1^1/_2$ fathoms approximately.

Galloper Current.

December 1937	0·1	S. 27°W.
January 1938	1·3	N. 26°E.
February 1938	2·0	S. 43°W.
Winter 1937/38	0·2	S. 77°W.

For each month, the vector average of the winds observed aboard the lightvessel has been computed; the winds were observed eight times daily and the following data are in miles per hour from a true direction.

Galloper Wind.

December 1937	1·4	N. 49°W.	(246; 15·8)
January 1938	11·8	S. 68°W.	(247; 19·2)
February 1938	3·3	N. 1°E.	(223; 21·0)

Of the two figures in brackets, the one on the left gives the number of observations of wind, and the other denotes the mean strength of wind in m.p.h.

Sandettié Current.

December 1937	0·3	S. 32°E.
January 1938	0·5	N. 66°E.
February 1938	1·5	S. 23°W.
Winter 1937/38	0·5	S. 4°E.

Of interest here are the results from the Varne. The water-flow past that lightvessel was calculated from observations made with the Drift Indicator at the depth of 6 fathoms.

Varne Current.

December 1937	4·2	N. 14°E.
January 1938	6·2	N. 23°E.
February 1938	2·1	N. 2°W.

Varne Wind.

December 1937	0·4	N. 2°E.	(248; 13·4)
January 1938	11·1	S. 63°W.	(244; 17·4)
February 1938	3·0	N. 13°W.	(224; 15·0)

It is of interest to note that at the Royal Sovereign lightship off Eastbourne, the excess of flood run (towards east) over ebb run (towards south-west) was as follows — the excesses being in miles per day:—

Royal Sovereign.

During December 1937	1·6
— January 1938	3·1
— February 1938	0·8

These data differ from each other in a manner which accords with the monthly variations just noted in the case of the Varne lightvessel.

For the Maas lightvessel I am able to set down data kindly supplied by Dr. VAN VEEN, whose values I have converted into miles per day.

Maas Current.

December 1937	2·9	N. 42°E.
January 1938	2·9	N. 40°E.
February 1938	1·0	N. 5°E.

Data for the Horns Rev lightship have been kindly sent to me by Dr. TÅNING and are as follows:—

Horns Rev Current.

December 1937	3·8	NNW.
January 1938	4·3	NNW.
February 1938	1·9	NNW.

There is a reason for presenting also the data from the Cromer Knoll lightvessel, and these were:—

Cromer Knoll Current.

December 1937	0·2	S. 74°W.
January 1938	1·2	S. 66°E.
February 1938	0·0	S. 52°W.

The reader will note that the increased flow from the Channel in January 1938 (as shown by the Varne data with which those of the Royal Sovereign are in keeping) was reflected more at the Galloper and even as far as the Cromer Knoll, than at the Sandettié. He will also see that during winter 1937/38 as a whole there was little flow past the Sandettié and Galloper lightvessels, and that during February, the Sandettié average water-flow was towards the SW. quadrant.

These conditions of current ruling in winter 1937/38, so different from those of one and two years before, may conceivably have had some determinative influence upon the fortunes of fish born at the time in the Southern Bight. That we shall one day know, and there is no reason to suppose that from now on we shall ever lack such data on winter currents as those just set down.

It is not proposed to publish another paper on this subject next year; workers who find the data of interest and of use, will be able to obtain them on application.

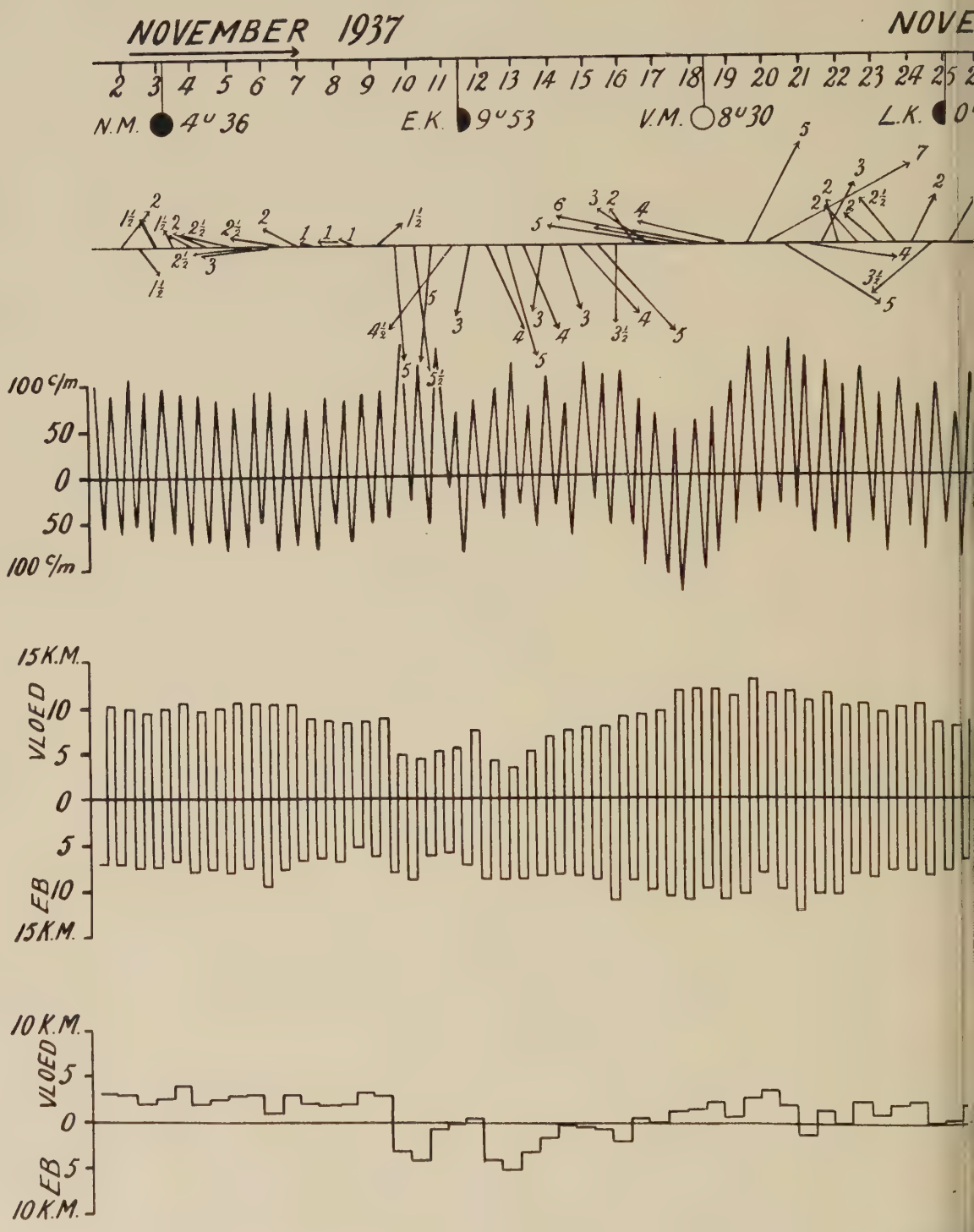
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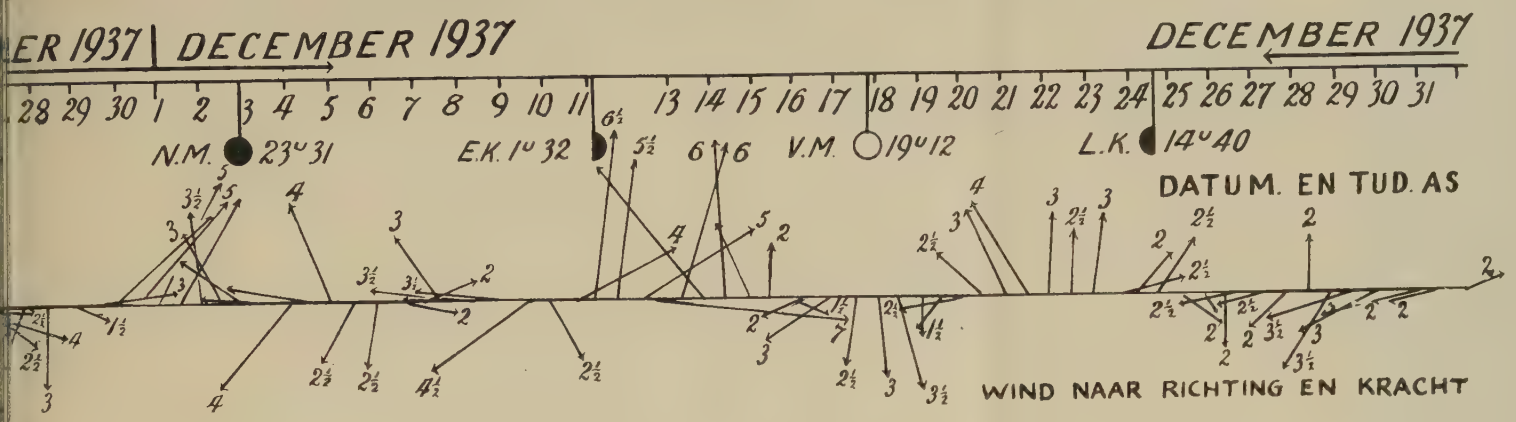
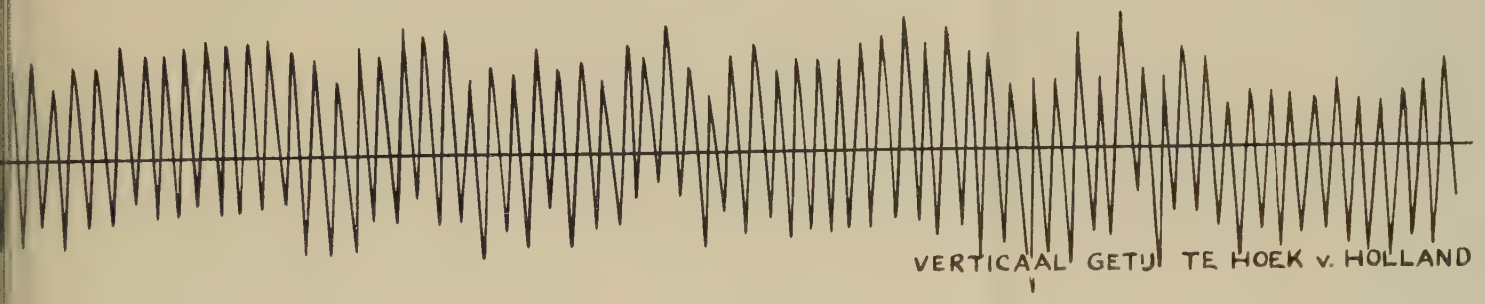
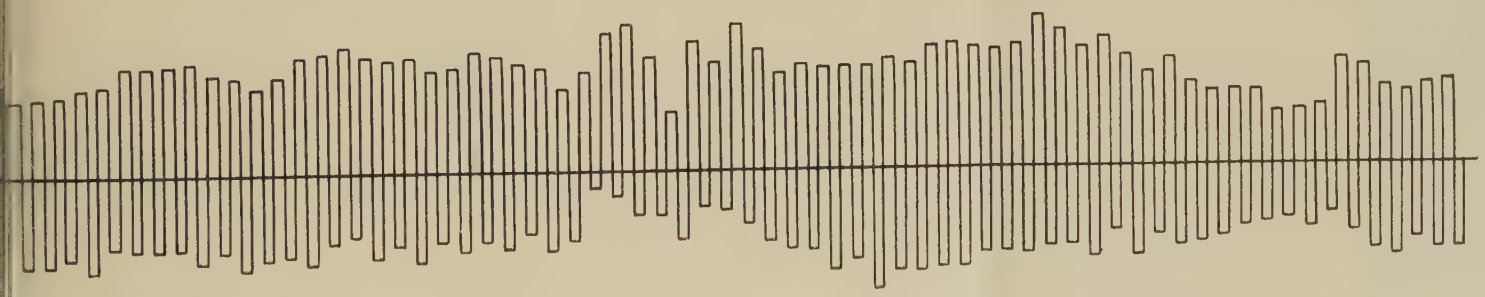
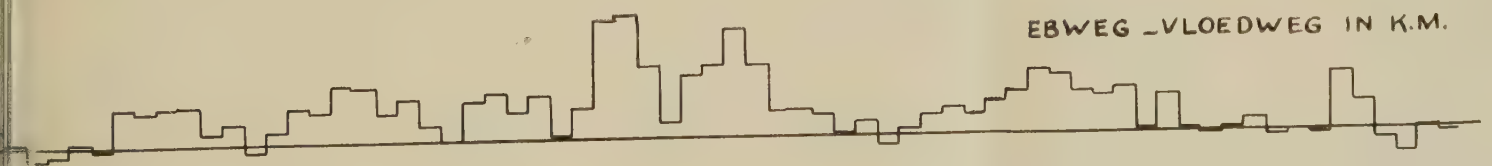
Fig. 1. Sh









RIJKSWATERSTAAT_DIR. BENEDENRIVIEREN
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2E HALFJAAR 1937

Results of Continuous Observations
d the Maas Lightvessel.

4.

Observations on the Herring Population in the Flemish Bight and the Eastern Part of the Channel in the Winter 1937—38.

By

J. J. Tesch.

('s Gravenhage).

om October 1937 till the end of January 1938 e again collected weekly samples of drift-caught ings, each containing approximately 200 fish, and e the usual observations of length, maturity, age race. In all 3292 fish were examined.

uring October—November the samples came tly from Smith's Knoll; from December onwards fishery shifted to beyond Cape Griz Nez, and y of the samples originated from near Fécamp. igree, for practical purposes, to regard the autumn winter herrings of the area between the points ed as one "population", though perfectly aware we are justified in assuming the existence of races (Le Gall's type "II" and "Dyck"), and shall have occasion to return to this matter in course of this paper.

ength. To begin with, the mean length of our e material was 25·43 cm., as against 25·70 cm. ne winter before. So there seems to have taken a slight rejuvenation of the stock, as appears the length-frequencies in Fig. 1. Small herrings 1—22 cm. were, however, not abundant this er (only 5·5 %). In the previous winter such ll fish were almost entirely lacking and we pointed t the time that the year-class 1933 had apparently l. Similar experiences were had by Le Gall, gson and Gilson, who investigated the same x.

e must point out from the outset that the Flemish t in October—November yielded on the whole what larger herrings than the Eastern Channel ecember—January. In the first area the mean h was 25·86, in the second only 24·70 cm. It is unlikely that this difference of more than 1 cm. is to be ascribed to the width of the mesh used, as will be explained later on.

The length-frequencies (in thousands) in the last two winters were as follows:—

Table I.

cm.	21	22	23	24	25	26	27	28	29	30
1936—37	—	10	34	146	279	234	196	82	15	3
1937—38	8	48	84	142	184	251	199	72	11	1

Age. Our chief interest lay naturally in the quantitative distribution of the year-classes. A rather striking fact revealed itself in the first half of the course of our investigations: contrary to expectations "threes" and "fours" failed to appear in appreciable quantities during October and November in the Flemish Bight. In the "fours" this was rather to be expected, as the year-class 1933 had already turned out to be a bad one, but now a like fate seemed to have befallen the three-year-olds. The "threes" rose considerably in quantity and temporarily outnumbered even the "fives", but finally failed to give a good account of themselves. Yet it is chiefly attributable to these "threes" that the average age in all the samples together was almost exactly one whole year younger than in the preceding winter, viz. 5·28, as against 6·26 in 1936—37.

In Table II the percentages (calculated from 3292 fish) are shown for the whole period and for all four months.

Table II.

.....	3	4	5	6	7	8	9	10 and +
of birth.....	1934	1933	1932	1931	1930	1929	1928	1927 and —
—27. XI. Flemish Bight.....	11·45	18·15	31·85	16·84	7·01	11·92	2·20	0·58
II—25. I. Beyond Cape Gris-Nez ..	25·58	20·51	24·78	14·42	4·71	8·62	1·01	0·37
le period.....	17·38	19·14	28·89	15·83	6·05	10·54	1·70	0·47

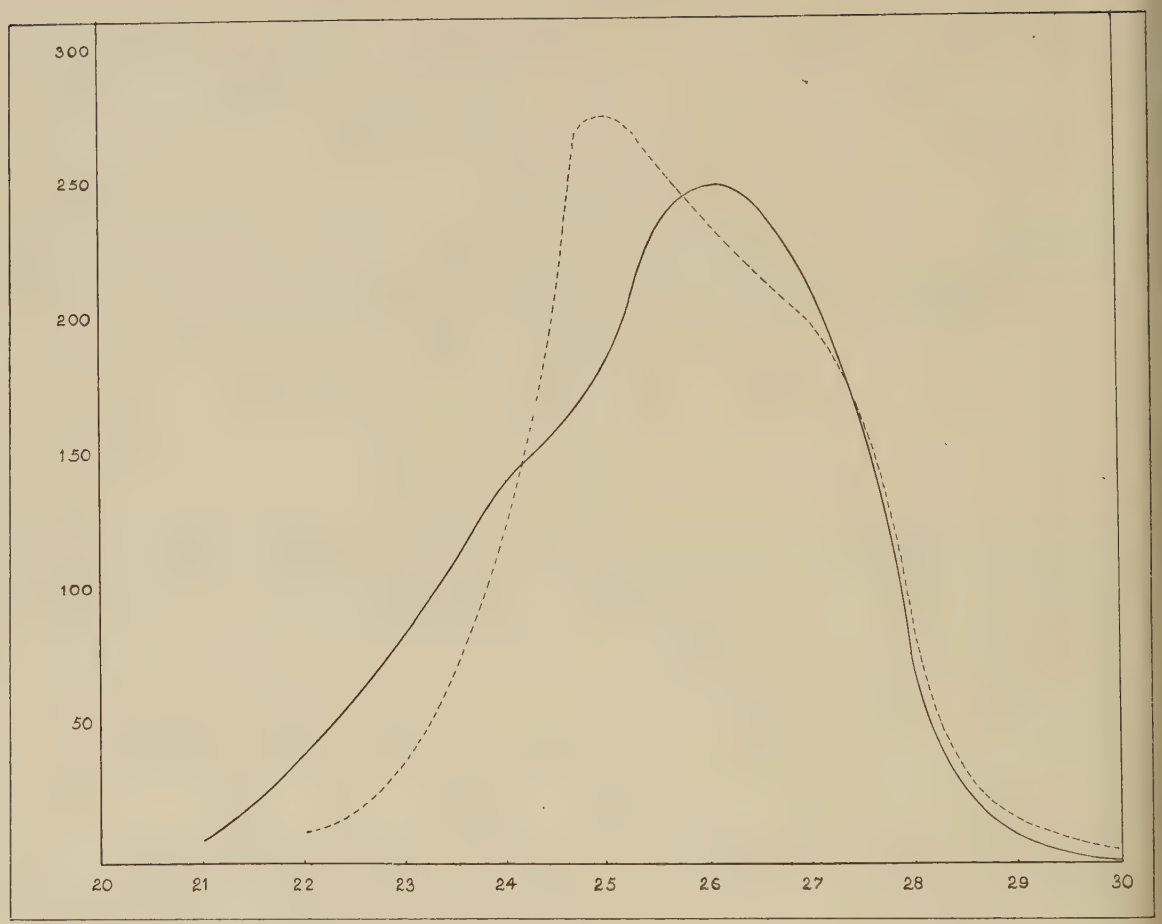

Fig. 1. Length-Frequency Curve of Herrings in the Flemish Bight and off Dieppe.
Continuous curve:— winter 1937—38, broken curve:— winter 1936—37.

These quantitative strengths of the year-classes are illustrated in Figs. 2—4.

The outstanding broods are those of the ages 5 and 8; we might of course expect this, as the year-classes of 1932 and 1929 had shown themselves in earlier years to be particularly strong. The brood of 1931, now 6 years of age, is also of importance. The preponderance of the "fives" causes the high top, and the relative strength of the "eights" a slight bulging, in the graph in Fig. 1. On the other hand we have still the poor year-class of 1930 in the stock which, being now 7 years of age, will gradually die out.

More interest is of course to be attached to the two youngest year-classes. Why did we find the "threes" so rarely in the Flemish Bight, yet in greater quantities in the Eastern Channel? And if the "fours" of the year 1933 were scanty, as they likewise proved to be the year before, could their comparative failure be ascribed to a regional failure and, if so, in what region? And finally, these two year-classes, contrary to the usual cycle, having appeared in October, is there any solution to this puzzle in hydrological or, rather, ecological factors? This last question seems at the present state of our information unanswerable, but we may try to examine the other two.

Counting vertebrae yielded the following frequencies in the "threes".

Table III.

Flemish Bight Oct.—Nov.		Eastern Channel Dec.—Jan.	
55	5	55	10
56	95	56	153
57	106	57	183
58	8	58	6
	214		352
Av. ±	56·55	Av. ±	56·53
stand. err. ±	0·0330	stand. err. ±	0·0311

So the three-year-olds undoubtedly belong, through out the period of investigation, to the same Southern North Sea type, the Downs herring. On the other hand it is remarkable that they occurred chiefly i

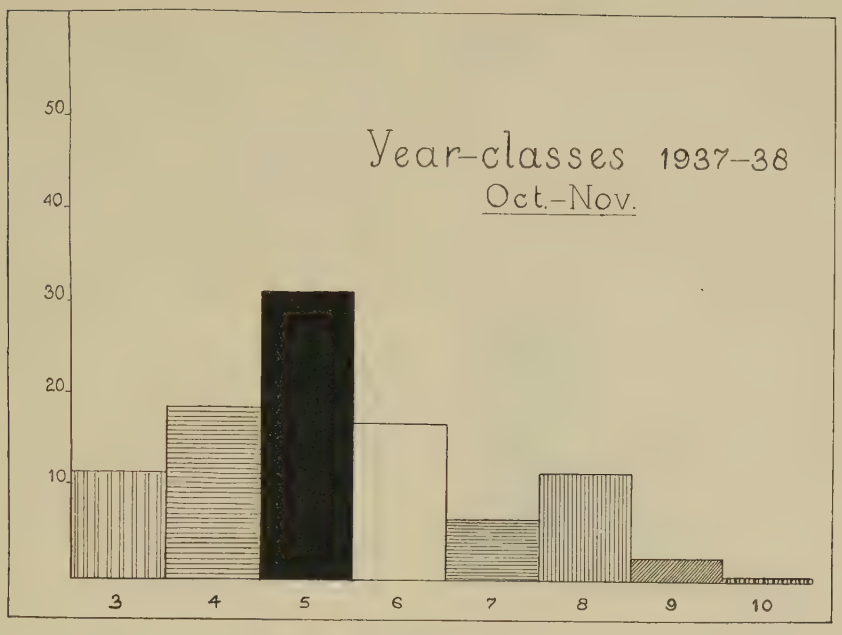

Fig. 2.

region beyond Cape Griz Nez. Their comparative city in the earlier samples must, then be due either rratic sampling or to some fault in the fishery, ch missed the youngest herrings.

s to the next year-class the question seems to omewhat different. The frequencies of vertebrae, as given in our next table (IV), point to the possibility that the "fours" of October—November originate from the Downs herring, while those of December—January are to be ascribed to the Channel herring. The standard error of difference is 2·46, and accordingly there is some probability that different races

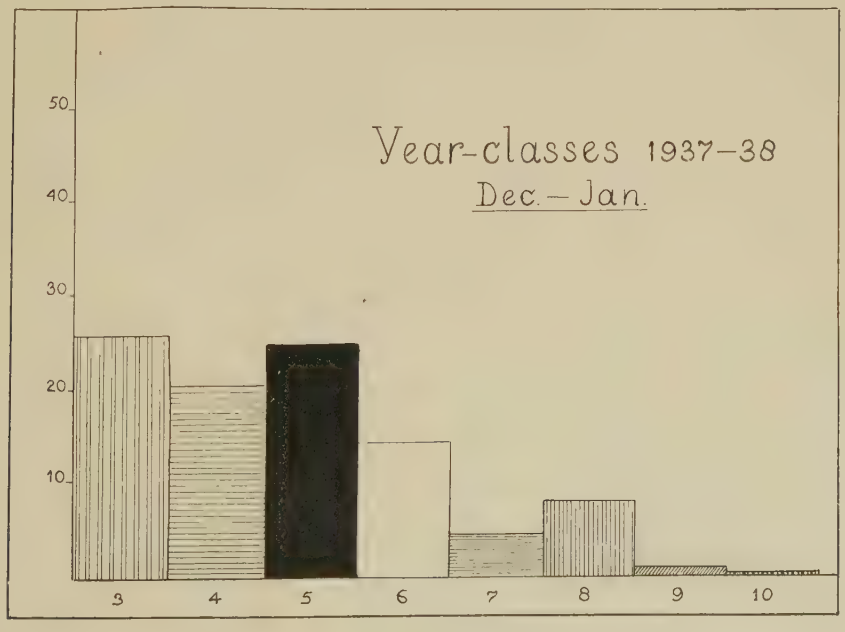

Fig. 3.

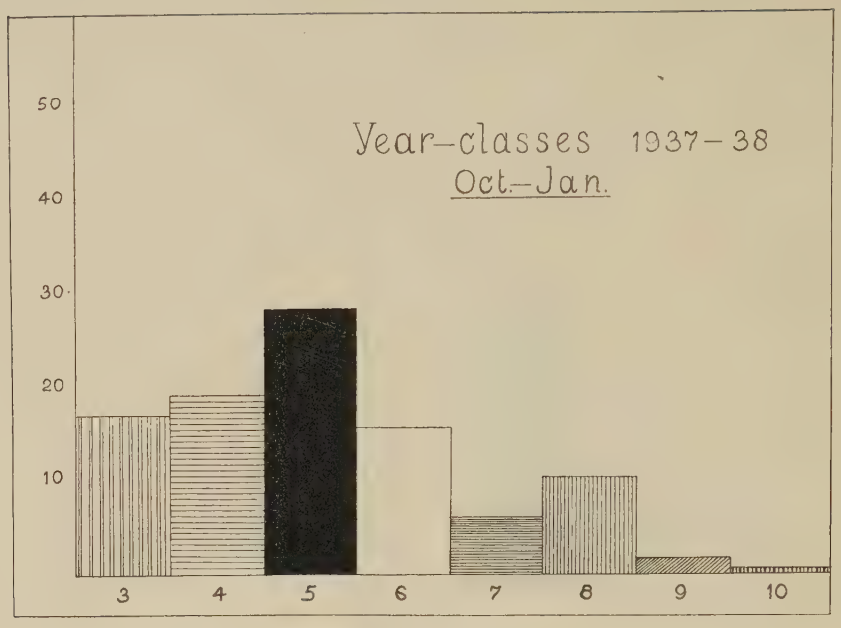

Fig. 4.

exist with which we have to deal here. We may assume, therefore, that the scarcity of the 1933 brood was not ascribable to a failure in either the one or the other of the areas named, but that the brood originated in both regions.

Table IV.

Flemish Bight Oct.—Nov.		Eastern Channel Dec.—Jan.	
55	10	55	8
56	152	56	97
57	166	57	158
58	10	58	14
	338		277
Av. ± stand. err.	56·52 ± 0·0329	Av. ± stand. err.	56·64 ± 0·0375

Race. Every winter the vertebrae of samples of our herrings were counted and frequency tables, in connexion with maturity, drawn up. Comparing the tables relating to the last three winters it seemed advisable to publish some of them, at least those which showed fairly conclusive results.

As to Stage V, however uncertain its assessment may be, we must distinguish two periods, for the moment regardless of locality of capture, namely, October on the one side and November—December on the other, as it always happened that full herrings at the beginning of the fishery were of a different type from those of later months.

Stage VII, which was the next abundant phase, was best considered over the last three months of the year taken together. The next one, that of January, extending somewhat into February, has been compared with this period for Stage VII. In Table V the results obtained during the last three winters are shown.

Table V.

Stage V.

Year	Month	Serial letter	Number exam.	Av. ± stand. err.	St. err. of diff.
Winter 1935—36	Oct. '35	(a)	576	56·356 ± 0·027	(a) (b)
	Nov. to Dec. '35	(b)	1121	56·634 ± 0·018	8·53
Winter 1936—37	Oct. '36	(c)	560	56·434 ± 0·026	(c) (d)
	Nov. '36	(d)	752	56·609 ± 0·023	4·65
	2nd hlf of Nov.	(e)	375	56·680 ± 0·031	(c) (e) 6·15
Winter 1937—38	Oct. '37	(f)	855	56·426 ± 0·021	(f) (g)
	Dec. '37	(g)	501	56·615 ± 0·021	5·50

Stage VII.

Winter 1935—36	Oct. to Dec. '35	(a)	196	56·403 ± 0·029	(a) (b)
	Jan. to Febr. '36	(b)	1023	56·539 ± 0·020	3·86
Winter 1936 –37	Oct. to Dec. '36	(c)	382	56·508 ± 0·034	(c) (e)
	Jan. '37	(d)	226	56·558 ± 0·041	2·48
Winter 1937 –38	Oct. to Dec. '37	(e)	209	56·378 ± 0·040	(e) (f)
	Jan. '38	(f)	331	56·553 ± 0·035	3·29

› decide whether we are justified in distinguishing races, the standard error of difference has been ulated in most cases. We see from the above · that in Stage V two races are clearly defined, · this standard error varies from about 8 to more 4, when we compare Stage V in October and ovember—December, or whatever the case may n the three last winters. *This stage of maturity gs therefore to the Downs herring in October, and ges over to the Channel type in November or nber.* This feature has already been mentioned ır former paper of 1934 (Rapp. et Proc.-Verb. LXXXIX, 1934).

to Stage VII it seems a general rule *that all pent herrings in the period October to December g to the Downs herring.* As may be learned from ıst column in Table II there is a strong probability *in January these spent herrings are largely a ıre of the two races,* but the standard error of ence does not rise above 3·9. It would probably › in February, but we could not obtain sufficient in that month.

LSON's observations on spent herrings off the an coast in 1930—1931 (Ann. de l'Inst. d'Et. d'Ostende, Mém. 1, 1931, p. 38, Diagr. 17) have dy demonstrated that at the end of January occurs a "critical period" in which "poly-dylous" fishes replaced "oligospondylous" ones me extent, the averages of vertebrae S rising 56·61 in the second half of January to 56·75 e next fortnight. Both these averages are rather but as the author couples his race investigations year-classes and the numbers examined in each class are not given, it may have happened that w individuals have been dealt with in each case.

owth. We have calculated the mean lengths of ear-classes in recent years and the results are shown in Table VI.

e variants of length in each year-class fluctuate r widely, but on the whole there is a good agree- in the mean over four winters. In our drift-net lles the mean length of the "threes" may be ned to be too high.

e frequently observed rule that on the average a herring is as old as its length is above 20 cm. may be said to hold fairly well, though of course with the necessary reservations as applied to individual fish. This rule is applicable to the year-classes 3 to 6 (inclusive); from the age of seven onwards the mean length falls short of the assumed year-class, the more so the more advanced is the age of the individual fish. Whether this is an example of mesh selection by the drift-net (which does not adequately sample the older and larger herrings), it is as yet impossible to decide.

Another, and more remarkable, feature which we noted last winter is the inferior size of herrings in the Eastern Channel, when compared with the same year-class in the Flemish Bight. The difference, except for the "threes", in which it is as much as a whole centimetre, is demonstrated in the following Table VII; it is invariably about 0·40—0·50 cm.

The most obvious supposition is that the cause of the difference is to be sought in the kind of nets used. HODGSON (Journ. du Conseil, VIII, 3, 1933) has provided ample evidence that the size of the herrings caught depends largely on the width of the mesh. We might, then, suppose that the samples of October —November were caught with a larger mesh than those of December—January. The odd thing, however, is that the opposite happens to be the case. Whenever the kind of gear has been recorded, all October—November samples were taken with Scotch drift-nets, the December—January samples with Dutch nets. As the latter have a wider mesh (about 30·5 rows to the yard) than the first-named, we should expect the smaller fish in the earlier samples. On the other hand, it should not be forgotten that Dutch nets are tanned and oiled, while Scotch nets are tanned only, and accordingly the shrinkage of Dutch nets may in the long run result even in an actually smaller mesh.

Whatever the explanation may be, the discrepancy between the width of meshes and the size of fish taken by them is one more reason for not relying on the catches of drift-nets alone, if a characterization of the stock is desired. We shall, therefore, need measurements of trawl herrings as well.

Table VI.

Winter	Mean Length in cm. at Age —							
	3	4	5	6	7	8	9	10 and +
35	23·13	24·41	25·40	26·26	26·76	27·30	27·77	28·14
36	23·06	24·18	25·50	26·27	26·93	27·28	27·89	28·33
37	23·17	24·98	25·46	26·42	26·70	27·18	27·28	28·16
38	23·23	24·57	25·82	26·31	26·55	27·19	—	—
Mean	23·15	24·53	25·54	26·31	26·73	27·24	27·64	28·21

Table VII.

Period	Locality	Mean Length in cm. at Age —					
		3	4	5	6	7	8
Nov. 1937	Flemish Bight	23·82	24·76	25·99	26·52	26·74	27·33
37—Jan. '38	Eastern Channel	22·86	24·33	25·53	26·00	26·17	26·92

5.

Notes on the Biology of the Cornish Pilchard.

By

C. F. Hickling.
(Fisheries Laboratory, Lowestoft).

In the accompanying figure are shown some of the results to date of an investigation of the biology of the Cornish Pilchard *Sardina Pilchardus* Walb. These results are calculated as monthly means, for the present purpose.

Feeding. These results are obtained by collecting and weighing the stomach contents of 50 specimens in each sample, and then calculating the average weight of food per stomach. It will be seen that the amount of food present in the stomachs was greatest in the months of April, May, June, and July, of each year, that there was a secondary increase in the quantity of food in October of each year, and that feeding was least in the months between November and February.

An investigation into the nature of the food showed that in the months of March and April the food was mainly diatoms, in May and June mainly copepods and decapod larvae, in July, August and September, also, copepods and decapod larvae, together with abundant peridinians and diatoms, and in October chiefly diatoms again. The double nature of the annual crop of diatoms is clearly reflected in the food of the pilchard. The scanty food present in the stomachs in the winter months is mainly unrecognisable, but it includes diatoms, amphipods, and, especially in February, cirripede nauplii.

Spawning. The average weight of testis and ovary in fish of 22 cm. is taken to illustrate this cycle. The weight is least in August of each year, and increases to a maximum in April, May, and June. Thus the time of the maximum development of the gonads is also the time of heaviest feeding, a state of affairs contrary to that found in other species of fish.

The male produces a greater weight of gonad than the female, and is ripe over a somewhat longer period.

Condition. Fish of 22 cm. will again be taken to illustrate the seasonal change in the mean weight of a gutted pilchard of given length, that is, of the fish without gut or gonads. The amplitude of this fluctuation is great, varying from about 72 to 92 g. The average weight is least in March and April of each year, increases to a high level in July, decreases somewhat until September and October, and then increases to a new maximum in December and January. There is then a very rapid loss of weight until March and April.

These changes may be compared with the income of the fish, in the form of the food, and the expenditure of the fish in breeding and maintenance. The rapid loss in condition between December and January, and March and April, occurs when feeding is at a minimum, and when, nevertheless, the gonads are ripening. In April and May feeding becomes heavy, and suffices to bring about a recovery in the condition of the fish as well as to complete the ripening of the gonads. The reason for the slight loss of condition between July and October may be the decreased rate of feeding in conjunction with the growth which is still taking place at this time of the year, and to an accelerated metabolism due to the high temperature of the sea.

The secondary recovery in condition which takes place in December may be the result of the increased rate of feeding in October, which occurs at the time when growth has ceased, and when the gonads are still quiescent.

It will be seen that, just as the male produces a heavier gonad than the female, the body weight of the female is usually somewhat greater than that of the male.

Intestinal Fat. The graph refers to the results given by fish of 20—22 cm.; the fish were classified as fat if abundant fat was present in the mesentery. The seasonal changes in the percentage of fish containing abundant abdominal fat are very similar to those of the mean weight of the gutted fish, but tend to occur slightly later. Thus the condition of the fish begins to improve in April, but the storage of intestinal fat not until May or June. Similarly, the loss of condition of the fish, which begins in July, is not followed by a loss in intestinal fat until August. Possibly the intestinal fat is drawn upon to help to make up the loss in condition of the flesh which occurs in the late summer.

Fat Content. This and the other chemical analyses were done upon that part of the fish which is useful to the canning industry, namely, the fish after the removal of the gut, gonads, head and tail, and scales. The flesh was minced, and a portion of the minced flesh taken for analysis. The fat content was determined, firstly by bulk extraction with ether, after digestion with hydrochloric acid; and later, by Soxhlet's method.

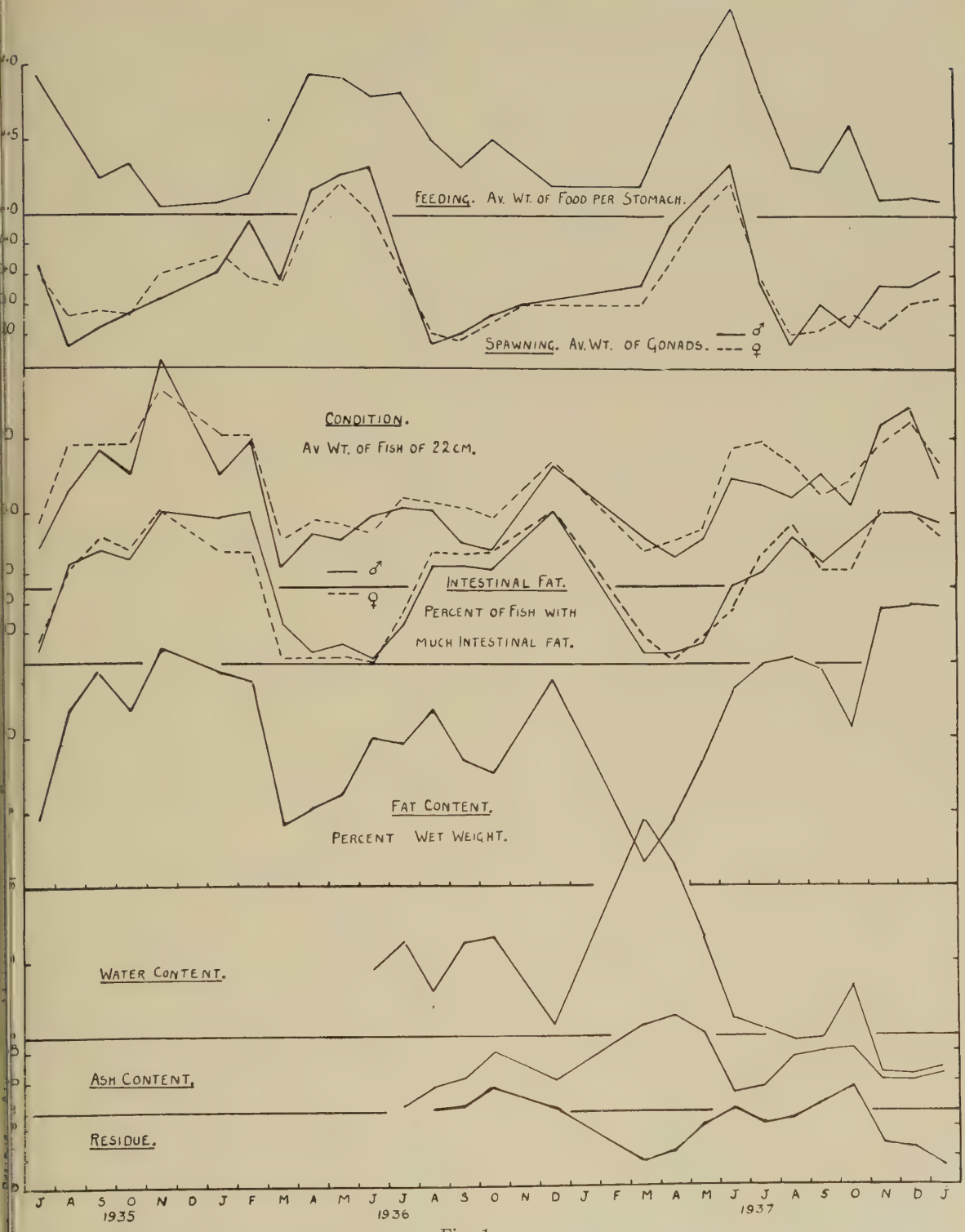
FEEDING. AV. WT. OF FOOD PER STOMACH.
SPAWNING. AV. WT. OF GONADS. ♂ ♀
CONDITION.
AV WT. OF FISH OF 22 CM.
♂
♀
INTESTINAL FAT.
PERCENT OF FISH WITH
MUCH INTESTINAL FAT.
FAT CONTENT.
PERCENT WET WEIGHT.
WATER CONTENT.
ASH CONTENT.
RESIDUE.
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J
1935
1936
1937

Fig. 1.

The graph shows that the fat content, expressed as a percentage of the wet weight, fluctuates seasonally in a way almost identical with the fluctuations in condition.

Water Content. The water content, as determined by evaporation to a constant weight, first on a water bath, and finally in the electric oven at 80°C., varies inversely with the fat content.

Ash Content. This was determined by combustion, and the graph shows that the ash content fluctuates in a manner similar to the water content, and therefore inversely with the fat content and the average weight of the fish.

When the water, fat, and ash content of the flesh are raised to the average weight of the fish, it is found that, subject to experimental error, there is little seasonal variation in the weight of water and ash present in a fish of given length. Water and ash, therefore, form a frame into which fat is stored, and from which it is withdrawn, these changes being largely responsible for the changes in weight of the fish.

Residue. Water, fat, and ash, added together, do not make up a constant percentage of the total composition of the fish, and there is a seasonal fluctuation in the percentage of the residue. This, which is presumably mainly protein, appears to reach a maximum in October, and to decrease to a minimum in March. It may be that protein is used up in the nourishment of the gonads, and to help to maintain the fish during the winter, when feeding is at a minimum.

This article is a preliminary note only. The full results will be published when the series of observations is complete, when they can be compared with those of RAMALHO and others.

6.

Salmon-Markings in Esthonia and the Results obtained up to the present Date.

By

Edw. Reinwaldt.

(Communicated by T. H. Järvi.)

ce 1932 parr hatched in the Narva River in sthonia have been marked annually as follows:—

.....	1932	1933	1934	1935	1936	1937
marked..	40	96	358	246	397	428

otal of 1565 specimens. The fish have been caught g the autumn from September to November, he markings have been made with round silver of 9 mm. diameter bearing the letters EV, ng that the marking has been carried out by sthonian Ministry of Agriculture. The disc is hed to the dorsal fin. The following sizes of fish been marked the majority being in their second ear.

.. < 15·0	15·0— 19·5	20·0— 24·5	25·0— 29·5	30·0— 36·0
.. 0·8	74·3	20·9	2·9	1·1

to the present a total of seven specimens of narked fish have been caught; of these three taken in the Narva River itself, the remainder near the southern coast of Finland in its eastern as indicated below in greater detail.

EV. 400. Marked 19th October 1933, male, length m. Caught 4th March 1935 at Uusikirkko kala). The length was then 41 cm. (from tip of 4 cm.) and the weight 0·7 kg. The scale is illud in the paper by Järvi and Menzies (Rapp. oc.-Verb. XCVII, Fig. 28, p. 28).

EV. 678. Marked 8th November 1934, length . Caught 28th December 1935 at Tyrisevä. ength was then 36 cm. (39 cm.) and the weight g. The scales showed that it belonged to the fe-cycle class.

3) EV. 514. Marked 1st November 1934, length 18 cm. Caught in the beginning of June 1936 near Vehkaluoto at the mouth of the Kymi River, i. e., about 5—6 km. of the city of Kotka. Weight then ca. 1·5 kg.

4) EV. 583. Marked 26th October 1934. Length then 18·5 cm., male. Caught 11th June 1937 at waters near Nuokko Island about 16 km. east of Kotka. Weight then 3·8 kg.

Although the number of recaptured salmon is fairly low, they nevertheless appear to indicate that the movement of the fish is along the coastal waters, and varying with the flow of the current — first to the east, then to the west, in other words according to the assumed route (dotted) on the map.

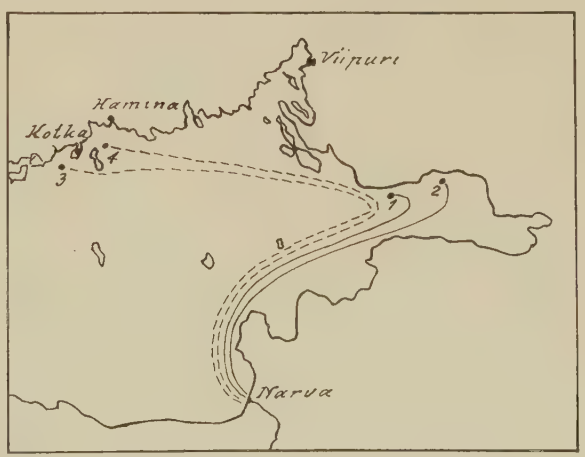

Fig. 1. Migration of Salmon, marked at the Narva River (Esthonia). 1. Uusikirkko; 2. Tyrisevä; 3. Kotka, Vehkaluoto; 4. Kotka, Nuokko.

7.

Ein Beitrag zur Rassenfrage beim schottischen Frühjahrshering.

Von

Dr. Wilhelm Erdmann, Hamburg.

meinem Bericht über die Schleppnetzheringscherei im Jahre 1935[1]) habe ich mitgeteilt, dass Herbst 1935 von deutschen Schleppnetzfischern dem Gat und in noch weit südlicher gelegenen eten frühjahrslaichende Heringe gefangen wurDer Grösse der Tiere und ihrer Wirbelzahl nach elte es sich um Frühjahrslaicher der nördlichen see, welche sich beim Abzug aus ihren Laichten gewöhnlich über die Gründe der nördlichen see zerstreuen und regelmässig im Herbst auf Fladengrund zu fangen sind.

e Probe, auf welche sich diese Mitteilung insdere stützte, erhielt ich am 8. Oktober 1935 vom dampfer "John Mahn" mit der Positionsangabe twa 56° N. und 1° O. für den Fangort; sie erhielt Protokollnummer 19 und soll auch im weiteren uf dieser Mitteilung mit dieser Nummer benet werden. Da mir aus der Literatur Angaben das Vorkommen nördlicher Frühjahrslaicher in eit südlich gelegenen Gebieten nicht bekannt n, kamen mir nach der Untersuchung der Probe e Zweifel an der Richtigkeit der Fangortsangabe; nochmalige Überprüfung bestätigte aber deren sslichkeit. Doch war es nicht möglich, die Tiere Zugehörigkeit und Herkunft genau einzuordnen, ne exakte Analyse der verschiedenen frühjahrsenden Formen der nördlichen Nordsee, welche taxonomische Behandlung dieser Gruppen erichen würde, noch nicht erfolgt ist. So blieb erhand nichts weiter übrig, als auf das ungewöhnfür die Fischerei aber bedeutsame Auftreten icher Frühjahrsheringe in den Gebieten südlich Gat hinzuweisen.

zwischen ist nun eine Arbeit von Wood[2]) über untersuchungen am schottischen Hering erien, welche meine Aufmerksamkeit erneut auf robe 19 vom Oktober 1935 lenkte. Im Kapitel IIB (S. 14 u. folg.) bespricht Wood die Ergebnisse seiner Untersuchungen am Frühjahrslaicher des Firth of Forth. Eine allgemeine Übersicht über die Proben der Jahre 1931—1936 aus diesem Gebiet zeigt beträchtliche Unterschiede in den Mittelwerten sowohl der Wirbelsummen (VS) als auch der Kielschuppen (K_2). Die Mittelwerte für VS schwanken in den genannten Jahren zwischen 56·716 und 57·010, diejenigen für K_2 zwischen 14·760 und 14·366. Überraschenderweise ergab die Analyse eines einzigen Jahrganges, des Jahrganges 1931, ähnliche Ergebnisse innerhalb ein und desselben Untersuchungsjahres. Im Februar 1934 zeigte dieser Jahrgang in den Proben vom Firth of Forth für VS den Mittelwert 56·987 und für K_2 den Mittelwert 14·775, während die entsprechenden Werte im folgenden Monat 57·118 und 14·298 lauteten. Wood schloss aus dieser Tatsache, dass ein Wechsel in der Zusammensetzung der Schwärme stattgefunden haben müsse. Ähnliche Schwankungen innerhalb desselben Jahrganges wurden auch in zwei Proben vom März des folgenden Jahres 1935 festgestellt. In der einen Probe vom 11. März besass der Jahrgang 1931 für VS den Mittelwert 56·981 und für K_2 den Mittelwert 14·547, wogegen derselbe Jahrgang in einer zweiten Probe vom 25. März für die entsprechenden Merkmale die Mittelwerte 57·132 und 13·932 aufwies. Hieraus folgerte Wood, dass die Heringe dieser beiden Proben verschiedenen Ursprungs sein müssten, und dass die Laichschwärme des Firth of Forth im Jahre 1935 keine einheitliche Laichgemeinschaft dargestellt hätten. "The difference between the last two samples received is so marked that the spawning stock in the Forth in 1935 did not form a homogeneous spawning community. The last sample is unique amongst the samples of Forth spawners examined in that it has a high number of vertebrae associated with a low number of keeled scales, the mean of which is less than 14·0, a feature which has been so far found typical only of the spring spawners at Shetland and its neighbourhood. Although spring spawners of northern origin appear regularly on the Fladen ground

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[1]) W. Erdmann, Der deutsche Schleppnetzheringsfang. Fischmarkt, N. F., Jahrg. 4, Heft 3.

[2]) H. Wood, Race Investigation of the Herring Population of Scottish Waters. Fisheries, Scotland, Sci. Invest., No. III.

in late autumn, it did not seem likely that they would extend their range as far south as the Forth estuary. Nevertheless the last sample obtained in 1935 suggested a connection with this stock."

Ein Vergleich der letzten Probe vom Firth of Forth mit Tieren desselben Jahrganges aus einer Probe vom Fladengrund vom Herbst 1934 bestärkte Wood in seiner Annahme noch mehr. Die Gegenüberstellung der Proben ergab für die Merkmale VS und K_2 eine weitgehende Übereinstimmung, welche sich auch in den Grössenverhältnissen der Tiere wiederholte, wie die folgende Übersicht 1 zeigt.

Übersicht 1. Charakteristische Werte des Jahrganges 1931 in zwei Proben vom Fladengrund und aus dem Firth of Forth (nach Wood[2]), S. 19).

	VSM	K_2M	LM
Probe Fladengrund, Herbst 1934	57·10	13·95	27·4
Probe Firth of Forth, 25. III. 1935	57·13	13·93	27·5

[Mittelwerte der Wirbelsummen (VSM), der Kielschuppen (K_2) und der Gesamtlänge (LM).]

"Wee also see . . . that the herring in the last Forth sample agreed very closely with the herring of the same age-class caught on the Fladen ground in the autumn of 1934, not only with regard to the numbers of vertebrae and keeled scales, but also with regard to size. . . . Taking all the ascertained facts into consideration, there can be no doubt that a large body of spring spawning fish belonging to the year-class 1931, which was present in spring in Shetland waters and in the waters between Shetland and Norway in April, May and June, came as far south as the Fladen ground in the closing months of 1934, and that some of them extended their range even to the Forth spawning grounds in the spring of 1935."

Unsere Probe 19 vom Oktober 1935 nun, so will mir scheinen, ist sehr geeignet, diese Befunde Wood's zu unterstreichen. Und wenn noch letzte Zweifel daran vorhanden sein könnten, dass nördliche Frühjahrslaicher so weit südliche Gebiete aufsuchen, Zweifel, wie solche etwa aus oben zitierten Worten Wood's selbst zu entnehmen sind — "Although spring spawners of northern origin appear regulary on the Fladen ground in late autumn, it did not seem likely that they would extend their range as far south as the Forth estuary" — so werden diese durch die Probe 19 endgültig zerstreut, wobei nicht unerwähnt bleiben soll, dass ich auch in anderen Proben aus diesem und benachbarten Gebieten nördliche Frühjahrslaicher feststellen konnte, wenngleich nicht in einem solch hohen Hundertsatz, wie dies in der Probe 19 der Fall war.

Die Probe bestand aus 200 Heringen, welche einzeln nach Gesamtgewicht, Gesamtvolumen, Gonadengewicht, Gonadenvolumen, Reifezustand, Alter, Länge und Wirbelzahl untersucht wurden. Kielschuppen wurden leider nicht gezählt, sodass uns für einen Vergleich mit den Proben Wood's nur die Merkmale Alter, Länge, Reife und Wirbelzahl beschäftigen können. Bei der Auswertung mussten 10 Tiere ausscheiden, da bei ihnen das eine oder andere Merkmal nicht festzustellen war. Trennen wir die Probe zunächst nach dem Reifezustand, bestimmt auf Grund morphologischer Merkmale der Gonaden, und zwar nach Geschlechtern getrennt, so ergibt sich das in der Übersicht 2 ersichtliche Bild.

Übersicht 2. Zusammensetzung der Probe 19 nach Reife in %.

Reifegrad ...	I	II	III	IV	V-VI	VII-VIII
♀♀	—	10·0	41·0	—	—	3·5
♂♂	—	9·5	25·5	6·5	—	1·0
Insgesamt..	3·0	19·5	66·5	6·5	—	4·5

Die Übersicht 2 zeigt, dass in der Probe 19 sowohl Herbst- als auch Frühjahrslaicher vertreten waren. Doch ist eine Trennung der beiden Gruppen voneinander allein auf Grund des Reifezustandes der Gonaden nicht ohne weiteres möglich. Im allgemeinen reifen, wie ich immer wieder feststellen kann, die männlichen Heringe auf bestimmten Stadien schneller als die Weibchen. Die 6 % Männchen des Reifegrades IV können ebensogut Partner der Weibchen des Stadiums III, also Frühjahrslaicher sein, als es sich bei ihnen auch um spät im Herbst laichende Tiere handeln kann. Beides war dann auch tatsächlich der Fall, wie ich am Statolithenbild feststellen konnte. Dass es möglich ist, an Hand des Statolithen verschiedene Laichgemeinschaften voneinander zu trennen, deutete ich schon in einer früheren Veröffentlichung an (Erdmann[3]). Wir müssen uns auch hier darauf beschränken, die Tatsache als solche herauszustellen, und es muss einer späteren, speziellen Arbeit vorbehalten bleiben, das Phänomen näher zu besprechen. So viel sei jedoch gesagt, dass die hierbei angewandte Methode über die von Lissner[4]) beschriebene hinausgeht, bei welcher eine solche Scheidung auf Grund der verschieden starken Ausbildung, bzw. Nichtausbildung der ersten Winterzone, des "Kerns" durchgeführt wurde, eine Methode übrigens, welche den Statolithen-"Leser" oft im Stiche lässt.

Die Statolithenbestimmung ergab, dass Probe 19 zu 78·5 % aus Frühjahrslaichern und zu 21·5 % aus Herbstlaichern bestand.

Die Übersichten 3a—3c geben die Zusammensetzung der Gesamtprobe nach Alter, Länge und Wirbelzahl wieder.

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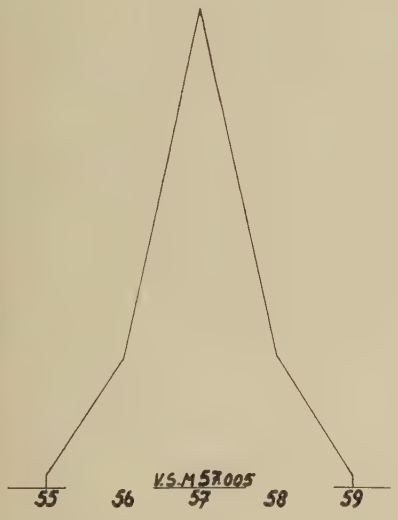
[3]) W. Erdmann, Untersuchungen über die Zusammensetzung der Heringsschwärme der nördlichen Nordsee 1936. Rapp. et Proc.-Verb., Vol. CV, 1937.

[4]) H. Lissner, Die Altersbestimmung beim Hering mit Hilfe der Otolithen. Ber. d. DWK., N. F., Bd. I, (1919–1923).

rsicht 3a—c. Zusammensetzung der Probe 19 Alter (a), nach Länge (b) und Wirbelanzahl (c).

a		b		c	
rg.	%	L	%	VS	%
33	2·1	—26	4·2	55	1·6
32	8·4	27	26·9	56	16·8
31	52·6	28	38·4	57	62·6
30	13·2	29	24·2	58	17·4
29	4·2	30+	6·3	59	1·6
28	12·1				
27	7·4				
ahl:	190	Anzahl:	190	Anzahl:	190
M[5])	4·97	LM[5])	27·99	VSM	57·005
				σ	0·687
				μ	0·05



b. 1. Variationspolygon des Merkmals VS aller Tiere in Probe 19.

u den wirklichen Verhältnissen besser gerecht zu n, ist es zweckmässig, bei der Berechnung des eren Alters für herbstgeborene Heringe in Proben nd der Monate Oktober bis März (n) volle Jahre, oben während der Monate April bis September $n + 1/2$) Jahre und entsprechend für frühjahrs- ene Tiere in Proben während der Monate April ptember (n) volle Jahre und in Proben während onate Oktober bis März ($n + 1/2$) Jahre einzu- . So berechnet, ergibt sich für die Probe 19 für erhältnis des Alters zur Gesamtlänge nach der el (LM — 20) — AM = W (ERDMANN[3])) für W ert +3·02. Im Mittel handelt es sich also um lwüchsige Tiere. Hieraus und aus der hohen

e mittleren Alter (AM) und mittleren Längen (LM) für Tiere unter 9 Jahren.

Wirbelzahl von 57·005 im Mittel kann man schliessen, dass Probe 19 zum allergrössten Teil aus nördlichen Frühjahrslaichern bestand, wie es auch das Variationspolygon der Wirbelsummen in Abb. 1 zum Ausdruck bringt. Ein noch klareres Bild erhalten wir, wenn wir die beiden Hauptkomponenten getrennt betrachten, wie dies in den Übersichten 4a—c und in der Abb. 2 geschehen ist, in denen die Herbst- und Frühjahrslaicher getrennt dargestellt sind.

Die Tiere sind nach dem Statolithenbild meist "blind", d. h. ohne Kenntnis des Reifezustandes der Tiere in Herbst- und Frühjahrslaicher geschieden worden. Wie die Mittelwerte der Wirbelsummen und besonders deutlich ihre Variationspolygone in Abb. 2 zeigen, ist allem Anscheine nach eine reinliche Scheidung erfolgt. Die Errechnung des Wertes W ergab für die Herbsttiere +0·82 und für die Frühjahrstiere

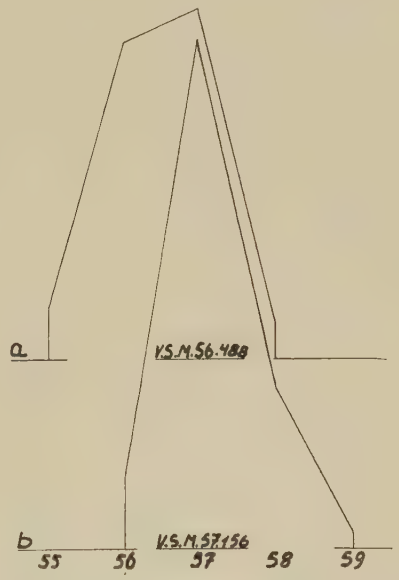


Abb. 2. Variationspolygon des Merkmals VS der Herbst- und Frühjahrslaicher in Probe 19; a = Herbstlaicher, b = Frühjahrslaicher.

+3·51. Uns interessieren hier vor allem die Frühjahrslaicher. Diese zeigen mit den Mittelwerten 57·156 für die Wirbelsummen und mit dem Wert +3·51 für W Charaktere, die typisch sind für frühjahrslaichende Formen der nördlichen Nordsee (s. ERDMANN[3])).

Über die Möglichkeit hinaus, auf Grund des Statolithenaufbaues Frühjahrs- und Herbstlaicher voneinander zu trennen, fand ich im Statolithenbild noch weitere Merkmale, die es ermöglichen, innerhalb der beiden Gruppen verschiedene Typen zu unterscheiden. Eine Analyse der Frühjahrslaicher der Probe 19 unter diesem Gesichtspunkt zeigte, dass von diesen 147 (78·5 %) Tieren 31 (15·4 %) zu dem einen unterschiedenen Typ (Typ a) und 116 Tiere (63·1 %) zu

Übersicht 4 a—c. Zusammensetzung der Probe 19 nach Alter, Länge und Wirbelzahl, getrennt nach Herbst (H.L.) und Frühjahrslaichern (F.L.).

a			b			c		
Jahrg.	% H.L.	F.L.	L	% H.L.	F.L.	VS	% H.L.	F.L.
1933....	—	2·1						
1932....	—	8·4						
1931....	—	52·6	—26.....	1·6	2·6	55.....	6·9	—
1930....	—	13·2	27.....	7·9	19·0	56.....	41·9	9·5
1929....	2·8	1·4	28.....	6·8	31·6	57.....	46·5	67·4
1928....	12·1	—	29.....	5·2	19·0	58.....	4·7	21·1
—1927....	7·4	—	30+....	1·1	5·2	59.....	—	2·0
Anzahl:	43	147	Anzahl:	43	147	Anzahl:	43	147
AM[5])	6·94	4·53	LM[5])	27·76	28·04	VSM	56·488	57·156
							0·696	0·604
							0·12	0·05

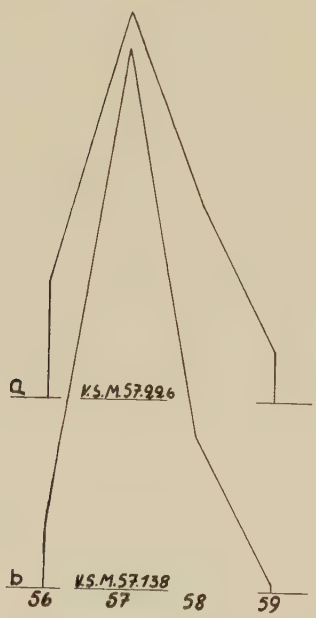


Abb. 3. Variationspolygon des Merkmals VS der beiden Frühjahrstypen in Probe 19; *a* = Typ *a*, *b* = Typ *b*.

dem andern Typ (Typ *b*) gehörten. Die Übersicht 5 bringt eine Gegenüberstellung der Werte LM, AM, W und VSM dieser beiden Typen (s. auch Abb. 3).

Übersicht 5. Mittelwerte für Länge, Alter und Wirbelsummen der beiden Frühjahrstypen in Probe 19.

	Typ *a*	Typ *b*
LM	28·81	27·84
AM	5·43	4·3
W	+3·38	+3·54
VSM	57·226	57·138
σ	0·795	0·55
μ	0·145	0·051

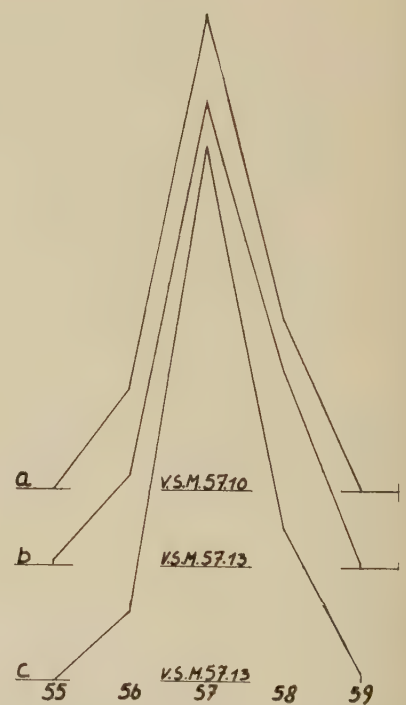


Abb. 4. Variationspolygon des Merkmals VS des Jahrganges 1931 in den Proben Wood's vom Fladengrund (*a*), aus dem Firth of Forth (*b*) und in der Probe Erdmann No. 19 aus dem Gebiet 56° N; N. 1 (*c*).

Auf die merkmalhaft verschiedene Ausbildung der Statolithen näher einzugehen, müssen wir ebenfalls der speziellen Arbeit über das Statolithenproblem vorbehalten. Von den 31 Tieren des Typs *a* gehörten 25 dem Jahrgang 1930, 4 dem Jahrgang 1931 und 2 dem Jahrgang 1929 an, von den 116 Tieren des Typs *b* gehörten 96 dem Jahrgang 1931, 16 dem Jahrgang

und 4 dem Jahrgang 1933 an; die beiden letzten gänge fehlten beim Typ *a*. Der Typ *b* zeigt mit n Mittelwert von 57·138 einen Mittelwert für der mit demjenigen des Jahrganges 1931 der e Wood's aus dem Firth of Forth vom 25. März bis auf die letzte Dezimal-Stelle übereinstimmt. Feststellung ist um so aufschlussreicher, als wir eben hörten, dass auch die Tiere vom Typ *b* in er Probe 19 zumeist diesem Jahrgang angehörten. lgen wir dem Beispiel Wood's und betrachten den Jahrgang 1931 in Probe 19 für sich, dann ten wir für VS den Mittelwert 57·130, eine ere Länge von 28·06 cm. und bei einem Alter iere von $4^1/_2$ Jahren für W den Wert +3·56. n wir nun einmal die beiden besprochenen n Wood's vom Fladengrund und aus dem Firth rth dem Jahrgang 1931 in unserer Probe 19 über und beachten wir, dass die Tiere dieses anges im Herbst 1934 etwa $3^1/_2$ Jahre, im Früh- 1934 etwa 4 Jahre und im Herbst 1935 etwa ahre alt waren, dann zeigt es sich, dass in allen gezogenen Charakteren eine fast völlige Über- mmung besteht (Übersicht 6 und Abb. 4).

sicht 6. Charakteristische Werte des Jahrganges n den Proben Wood's vom Fladengrund (Herbst , aus dem Firth of Forth (25. III. 1935) und in Erdmann No. 19 aus dem Gebiet südl. vom n Höhe d. Firth of Forth Anfang Oktober 1935).

Proben Wood		Probe Erdmann
Fladengrund Herbst 1934	Firth of Forth 25.III.1935	56°N. 1°O. Anf. Okt. 1935
27·4	27·5	28·0
3·5	4·0	4·5
— 3·9	— 3·5	— 3·5
57·10	57·132	57·130
?	0·639	0·561
?	0·004	0·056

b. 4 zeigt uns die entsprechenden Wirbelpoly- Die Übereinstimmung der in Übersicht 6 auf- hneten charakteristischen Werte und der Wirbel- one des Jahrganges 1931 in allen drei Proben bezeichnend, dass wir zu dem Schluss berechtigt lass die Frühjahrslaicher des Jahrganges 1931, in den Proben Wood's im Herbst 1934 auf ladengrund im Frühjahr 1935 im Firth of Forth urch unsere Untersuchungen im Herbst 1935 in ebieten querab vom Firth of Forth festgestellt n, derselben Gemeinschaft angehören. Die zum ich herangezogenen Merkmale sind in ihren werten und ihren Modifikationen typisch für slaichende Heringsformen der nördlichen e (s. u. a. Wood[2]) und Erdmann[3])), wenn wir n einzelnen noch nicht entscheiden können, für von den verschiedenen, in der nördlichen ee beheimateten Frühjahrsformen diese Werte teristisch sind.

mmenfassend können wir als das Ergebnis r Betrachtungen feststellen, dass das Vorkommen nördlicher Frühjahrslaicher in den Gebieten des Firth of Forth und dessen Nachbargebieten durch die Untersuchungen Wood's und durch unsere eigenen Untersuchungen als erwiesen angesehen werden kann. Wood's Annahme, dass Vertreter dieser Heringsformen im Frühjahr 1935 im Firth of Forth zum Ablaichen erschienen sind, gewinnt durch unsere Untersuchungen an Wahrscheinlichkeit.

Diese Schlussfolgerung wird trotz der aufgezeichneten, markanten Beziehungen eine ungeteilte Zustimmung nicht erfahren, da nicht allgemein einer verschiedenartigen Ausbildung der benutzten zählbaren und messbaren Eigenschaften ein taxonomischer Unterscheidungswert beim Nordseehering beigemessen wird. Vertreter dieser Anschauung sind vielmehr der Meinung, dass nicht nur eine verschiedenartige Ausbildung dieser Charaktere bei den Einzelindividuen als Modifikationen infolge von Umweltseinflüssen anzusehen seien, sondern dass auch die bei den Heringsuntersuchungen in verschiedenen Gebieten der Nordsee zu Tage getretenen, voneinander abweichenden Mittelwerte dieser Charaktere als Paravariationen zu werten seien, welche sich jederzeit durch eine Veränderung der Umweltsbedingungen umkehren lassen würden.

Folgen wir diesem Gedankengang, dann könnte gerade die Tatsache, dass vor allem ein bestimmter Jahrgang die hervorstechenden Eigenschaften, die uns zu der Annahme veranlassten, dass eine gebietsfremde Heringsform zum Ablaichen in den Firth of Forth eingedrungen sei, als Beweis dafür in Anspruch genommen werden, dass eben dieser Jahrgang aussergewöhnlichen Umweltsbedingungen ausgesetzt gewesen sei, welche zu der ungewöhnlichen Modifikation der genannten Charaktere geführt hätten. In Fortführung dieses Gedankens könnte gegen unsere Schlussfolgerung der Einwand erhoben werden, dass die Tiere des Jahrganges 1931 der drei besprochenen Proben keineswegs "gebietsfremd" sondern im Firth of Forth geboren seien, dass sie als Brut etwa durch ungewöhnliche Strömungsverhältnisse in andere, für den Firth of Forth-Hering fremde Aufwachsgebiete mit andersartigen Aussenbedingungen verschlagen worden seien, dort umweltsbedingt eine abweichende Ausbildung der Charaktere erfahren hätten, als erwachsene Tiere aber zum Laichen wieder in ihr Ursprungsgebiet zurückgewandert seien. Dem wäre entgegenzuhalten, dass es dann zumindest eigenartig sei, weshalb nur ein Teil dieses Jahrganges dies Los erlitten habe, da ja derselbe Jahrgang in Wood's Proben aus dem Firth of Forth innerhalb ein und desselben Monats ganz verschiedenartig ausgeprägte Merkmale zeigte. Gewiss, es liesse sich auch hierfür eine Erklärung finden, doch glauben wir nicht, dass sich ein Beweis dafür wird erbringen lassen.

Wir sind vielmehr der Ansicht, dass wir in den Variabilitätskurven der besprochenen zählbaren und messbaren Eigenschaften Bilder der den verschiedenen Heringsformen der Nordsee eigentümlichen und erblichen Reaktionsnorm vor uns haben, und dass die Plastizität der Merkmale den Rahmen dieser Reaktionsnorm nicht überschreitet und sich durch charak-

teristische Variabilitätskurven mit charakteristischen Mittelwerten ausdrücken lässt.

Kehren wir zu den Ergebnissen unserer Probenuntersuchungen und -Vergleiche zurück, so ist zu bemerken, dass durch sie keineswegs eine endgültige Klärung der Verhältnisse erfolgt ist, dass vielmehr im Gegenteil weitere Fragen und Probleme in die Heringsforschung hineingetragen worden sind. Welcher Gemeinschaft der verschiedenen nördlichen Frühjahrslaicher gehört die zweite von Wood zur Laichzeit im Firth of Forth beobachtete Gruppe an? Handelt es sich um aussergewöhnliche Erscheinungen oder wiederholt sich das Auftreten nördlicher Frühjahrslaicher im Firth of Forth öfter oder gar regelmässig? Hat eine Kreuzung der beiden Formen stattgefunden, findet eine solche regelmässig statt oder wird diese durch sexuelle Aversion verhindert? Handelt es sich um verschiedene Laichgemeinschaften des Firth of Forth, welche nebeneinander bestehen und jetzt erst als solche erkannt worden sind? Das sind einige der Fragen, die sich uns aufdrängen, deren Beantwortung aber nicht nur für unsere Anschauungen über das Rassenproblem beim Hering der Nordsee von allergrösster Wichtigkeit sein, sondern auch für die praktische Fischerei grosse Bedeutung gewinnen wird. Eine Entscheidung wird nur durch weitere systematische Untersuchungen herbeizuführen sein. Wir hoffen, in der Methode der Typisierung vermittels der Statolithen einen Weg gefunden zu haben, der uns dem erstrebten Ziel näher bringen wird. Doch steckt diese Untersuchungsmethode noch in ihren Anfangsstadien, noch wissen wir nichts über das Wie und Wo der Entstehung der verschiedenartigen Statolithen. Das eine greifbare Ergebnis aber haben unsere Untersuchungen schon gezeitigt, dass die eigentümliche Ausbildung der Statolithen mit besonders charakteristischen Mittelwerten für die Wirbelsummen und Kielschuppenanzahl, wie auch mit einem merkmalhaft verschiedenen Grössenwachstum korrespondiert.

8.

Variation of Year-Classes in an annual Concentration of Fish.

By

G. Gilson, Ostend.

riations in the composition of a shoal of fishes depend either on internal agencies affecting the g organism itself, or on certain changes occurring e environment.

culiar conditions observed in the sea may foretell ations in the normal composition of certain fish ntrations, or, inversely, changes appearing in the osition of a shoal may reveal that, in the past, liar conditions must have been prevailing either e constitution of the organism of the fishes or in environment.

fact, the nature and mechanism of the correlation een actions developing in the sea and qualitative antitative changes in the composition of shoals hes are not always easily detected, as will appear a few remarks on the work done by us in late s on spent herrings in the intermediate region een the Channel and the North Sea.

the diagram Fig. 1 are exhibited, in the form l "biological scale", the results of continuous rvations made at Ostend during the last eight s on the remarkable concentration of spent her- that come every winter regularly to the French- an coast to spend there a period of rest without ng. The step of 1937—1938 in the biological scale ditional to the diagram of the years 1930 to 1937 nted last year to this Committee.

tuation.

e superposition of the annual blocks in the first m on the left side of the scale, Fig. 1, when fol- l from 1927, above, downwards to 1938, shows luctuation in the concentration of three-year-old ngs considered at the time of their first appear- in the wintering station. The same fluctuation is clearly shown in the linear diagram Fig. 2, first al line on the left side. The fluctuation figures for ollowing years are pointed on the next five ver- lines on the right.

The percentage of the latest class, born in 1934, is rather high: 26 %, which is satisfactory as, in the past years, a high initial proportion has always prognosticated a good percentage in the subsequent years.

Oscillation.

Concerning oscillation, let us first remember that we have proposed the term as indicating the variation of the percentage in the evolution of one and the same generation of fish considered over a series of consecutive years. In the columnar diagram, Fig. 1, the oscillation may be followed from one year to the next by moving one column from left to right as one goes down one step. In the linear diagram, Fig. 2, the oscillation is marked by the dotted lines for each of the seven generations that have been under control since the year 1930.

The two diagrams, Figs. 1 and 2, show the remarkable fact that all year-classes (since the season 1930—1931) in their second appearance on the coast — that is to say at the age of four years — show a higher percentage than at three years. We have tried, last year, to explain this curious fact as follows:

> "The remarkable constancy of this phenomenon leads us to consider it as dependent upon an internal cause, inherent in the physiology of the fish. The fourth year seems to mark the critical age at which mortality in a group of living organisms, being very high immediately after birth and having greatly diminished for a certain period (until the fourth year in the case of herring), again becomes more intense down to the complete extinction of the group."

This year, however, we find for the first time a peculiar feature in the oscillation of one brood of spents, i. e., the young class born in 1933, being now one year older than in the last season ought to have shown a higher percentage than at its first appearance in 1936—1937.

1930—31

Number of herrings examined	1,167	
Mean weight of a day's capture	8,338	kg.
Total weight landed in the season	18,360,596	kg.
Mean value of 100 kg.	71	fr.
Total value of the season	13,008,930	fr.
Number of individuals destroyed	217,002,545	

1931—32

Number of herrings examined	783	
Mean weight of a day's capture	5,225	kg.
Total weight landed in the season	3,383,750	kg.
Mean value of 100 kg.	108	fr.
Total value of the season	3,642,806	fr.
Number of individuals destroyed	34,992,241	

1932—33

Number of herrings examined	1,000	
Mean weight of a day's capture	4,514	kg.
Total weight landed in the season	2,673,185	kg.
Mean value of 100 kg.	91.50	fr.
Total value of the season	2,446,867	fr.
Number of individuals destroyed	29,405,035	

1933—34

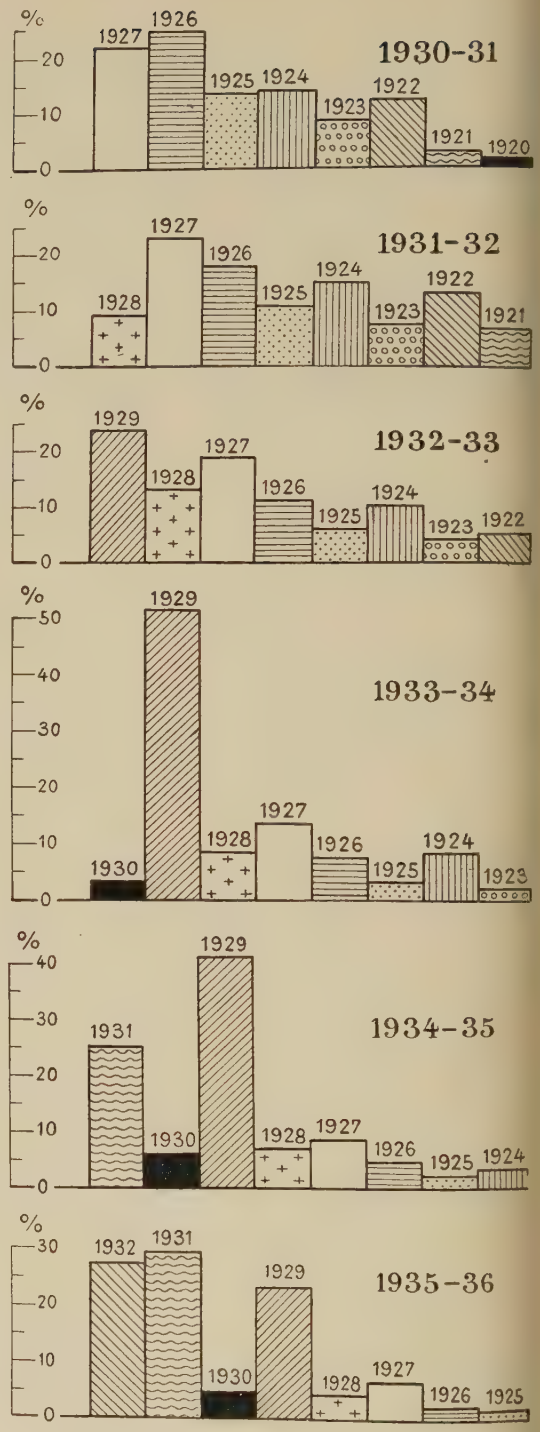
Number of herrings examined	1,479	
Mean weight of a day's capture	7,600	kg.
Total weight landed in the season	7,455,800	kg.
Mean value of 100 kg.	75	fr.
Total value of the season	5,577,441	fr.
Number of individuals destroyed	76,861,050	

1934—35

Number of herrings examined	1,200	
Mean weight of a day's capture	14,632	kg.
Total weight landed in the season	12,322,990	kg.
Mean value of 100 kg.	31.52	fr.
Total value of the season	3,856,044	fr.
Number of individuals destroyed	123,553,199	

1935—36

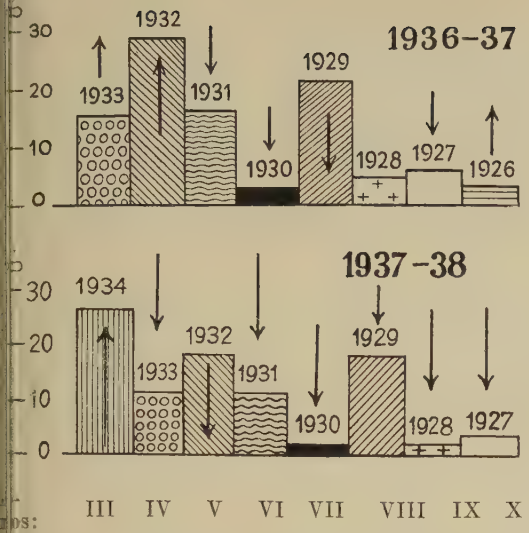
Number of herrings examined	1,300	
Mean weight of a day's capture	11,120	kg.
Total weight landed in the season	8,595,895	kg.
Mean value of 100 kg.	62	fr.
Total value of the season	5,328,754	fr.
Number of individuals destroyed	81,965,880	



Age-groups: III IV V VI VII VIII IX X

Balancing of percentages: number of individuals of each year-class in 100 fishes.

Fig. 1. Percentage number of individuals in each year-class.



ps:
hcing of percentages: number of individuals of each year-class in 100 fishes.
. Percentage number of individuals in each year-class.

1936—37

Number of herrings examined	625	
Mean weight of a day's capture	7,319	kg.
Total weight landed in the season	3,132,460	kg.
Mean value of 100 kg	72	fr.
Total value of the season	2,258,225	fr.
Number of individuals destroyed	31,211,269	

1937—38

Number of herrings examined	575	
Mean weight of a day's capture	5,568	kg.
Total weight landed in the season	807,425	kg.
Mean value of 100 kg	96	fr.
Total value of the season	774,629	fr.
Number of individuals destroyed	6,892,754	

Number of herrings examined in 8 years 8,129

stead of this we find that its percentage is distinctly r, it has fallen from 15·5% in 1936—1937 down % in 1937—1938. Its oscillation line in the dia- Fig. 2, instead of bending upwards as might be cted, takes a downward direction.

will be interesting in future seasons to follow ate of the class 1933 and to investigate the cause s low percentage appearing at the very time when ncrease was expected and to see whether this ction is final in the evolution of this class or will ended next year by a belated addition of herrings in their fifth year of age?

lis seems to show that the rule of an increase of percentage in a concentration of fishes between third year of age and the fourth is not an unbreak- law, and that certain accidental causes may ffere with the normal play of hydrographical and gical phenomena.

culiar conditions prevailing in the sea may act e fluctuation of fishes in two different ways:—

They may have an influence on the spawning and hing of the eggs and the welfare of the young e, and so affect the abundance of the new genera- which will appear in the third subsequent , as spents, after their first spawning season.

They may exert an immediate influence over hen living spent herrings and either drive them eat numbers towards the coast or lead them away it.

In both cases the fluctuation of the herrings in their usual resting station on the coast will be affected in one way or the other.

The low mean weight of a day's capture in 1937—38 seems to be in correlation with the particular conditions of wind and currents as observed on the "Sandettié" lightship during the period December 1937—February 1938. See the article by Dr. CARRUTHERS in the Appendices.

As to oscillation, we do not see how it could be directly affected by external actions.

Changes in temperature, salinity, pH, wind, motion of water, plankton etc., may very well have an influence on the total shoal of fishes living in a limited region and so affect the fluctuation in a succession of years. But no deviation from the normal play of natural forces could exert a selective action on one particular brood and affect its percentage separately in the composition of the annual concentration: all year-classes in the shoal would be affected at the same time, and their proportion would remain unchanged under the law of the balancing of percentages. The density of the concentration might be altered, but not the percentage of any of the classes: the oscillation line, no other trouble arising, would suffer no deviation.

We may conceive, however, that an entire year-class might be affected by a pathological or congenital predisposition, and so be liable to suffer from an alteration in the environment more deeply than the other

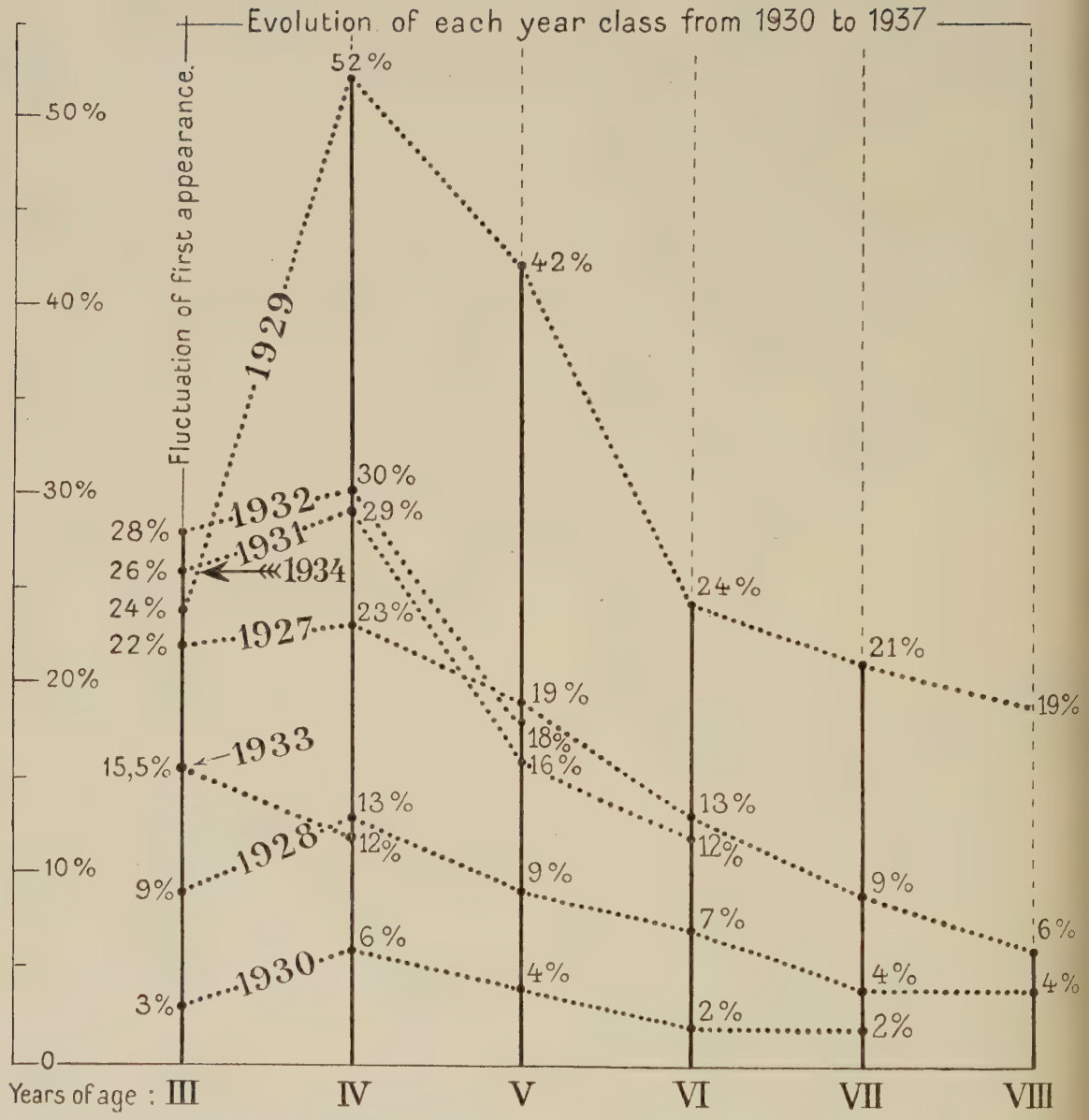


Fig. 2. Vertical lines = fluctuation. Dotted lines = oscillation.

ses in the shoal. But that very sensitiveness would he effect of internal peculiarities or dispositions the external actions would be only accessory in reduction of the number of the units.

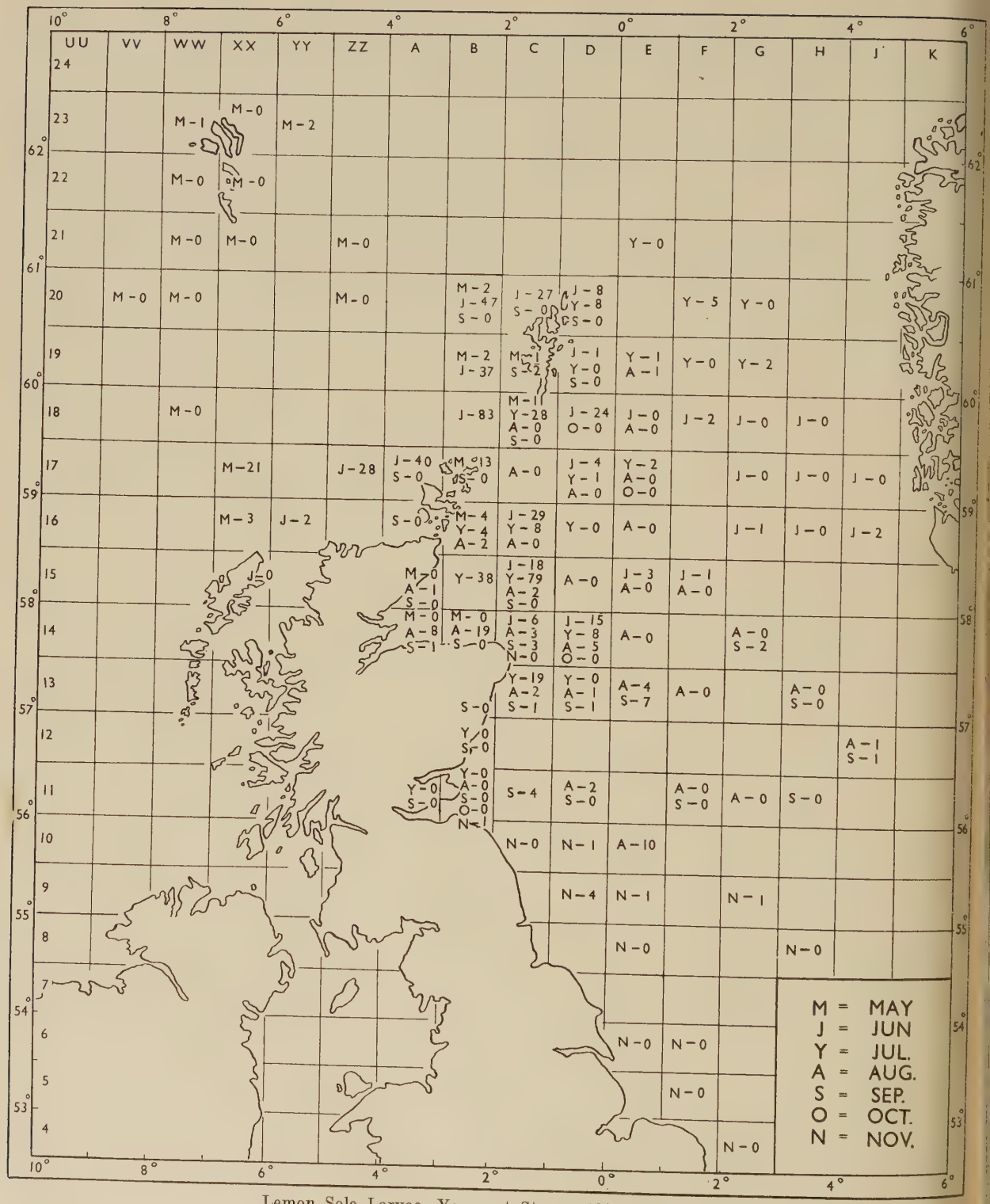
hese remarks lead us to the conclusion that whilst fluctuation of a community of fishes may be ted by external actions prevailing in the environ-t, the oscillation of each particular age-class pendent on internal organic conditions.

ecasts.

s predicted in 1937, the concentration of 1937— has shown a still good proportion of herrings of d 6 years, with an important remnant of the rkable class 1929. Besides that it was expected the class 1933, just appeared with a passable l percentage of 15·5% and supposed to be in its augmentative stage, would also supply a passable percentage. In fact, however, this was not the case and the unusual reduction of class 1933 in its 4th year was a surprise.

For the season 1938—1939 it is not possible seriously to draw a forecast, seven of the year-classes being already in their reduction stage, including 1933 that ought to have been in augmentation. We may expect that the remnant of the class 1934, then aged 4 years, will predominate, unless 1933 should show a not less unusual belated enrichment in units.

Quantitatively, there is no sign of a favourable fishing season and we can only wish for the fishermen that favourable meteorological and hydrographical conditions will prevail in the spawning grounds of the SW. and drive plenty of spent herrings towards Gris Nez and Ostend.



Lemon Sole Larvae. Youngest Stages. 1931. All Nets.

9.

Lemon Sole Larvae in Scottish Waters during 1931.

By

Bennet B. Rae, Aberdeen.

is paper deals with the first of a number of ears selected for the study of the larval lemon (*Pleuronectes microcephalus*) taken in the plank-ets of the Scottish research vessel "Explorer". term larva is here used to denote all stages up e completion of metamorphosis.

om the middle of February to the end of April llowing areas were sampled, but no larval lemon were caught.

ary:
rdeenshire coast, Sule Skerry, Minch.

h:
h, Butt of Lewis, Sule Skerry, North Rona, coast, West Orkney, North Orkney, West and, East Shetland, Northern North Sea, Fair East Orkney, Moray Firth, Aberdeenshire coast, of Forth.

:
of Forth, Central North Sea, Aberdeenshire , Northern North Sea, East Shetland, Fair Isle.

vestigations were resumed on 9th May and the larvae were caught near the Pentland Skerries he following day. Thereafter they were taken arly throughout the year until 17th November, which time the research vessel was withdrawn nnual overhaul. Between these dates a total 95 larvae was caught, details of which are given able 6 in which the larvae have been arranged hly according to various developmental stages. g to the preservation of the larvae in weak alin, characteristics based on pigment have been t unreliable in distinguishing different stages, so little stress has been laid on this feature.

Developmental Stages.

In spite of careful search through the collections no specimens with complete yolk-sacs were found and indeed only a few of the 89 larvae included in the youngest stage retained traces of the yolk. The following stages are defined for the purposes of the present report.

Stage 1. A pronounced depression in front of the anus caused by absorption of yolk-sac, more or less similar to that illustrated by Ehrenbaum (2) in his figure "d" and by McIntosh (4), Fig. 4, Pl. XI.

Stage 2. No depression in front of the anus: expansion of the marginal embryonic fins. The caudal fin appears in the form of a translucent portion on the embryonic fin near the ventral half of the first pigment spot, *vide* Petersen (5), Fig. 16.

Stage 3. Body deeper and embryonic fin broader. Fin rays are now visible in the caudal fin though there is no indication of the notochord bending upwards. The "*a*" and "*b*" pigment spots are now represented on the dorsal region, *vide* Petersen's Figure 17.

Stage 4. The notochord is definitely heterocercal and the caudal fin much developed. The body is deeper and traces of fin-ray supports are visible at the base of the embryonic fin. The left eye is beginning to migrate, *vide* Petersen, Fig. 18.

Stage 5. The heterocercal condition is more advanced. Fin-ray supports are well developed and the fin-rays of the dorsal and ventral fins extend about half-way to the margin of the embryonic fins. The eye is showing above the head, *vide* Petersen, Fig. 19.

Stage 6. No trace of embryonic fin remains. The dorsal and ventral fins are separated from the caudal fin. The pectoral and pelvic fin rays are now rapidly developing. The body is deeper and the pigmentation

more marked. The eye is advancing over the ridge. This stage includes all individuals up to the commencement of life on the sea bottom when metamorphosis may be regarded as complete, *vide* Figures 20 of PETERSEN and "*h*" and "*i*" of EHRENBAUM.

Fishing Gear.

The nets in general use on the "Explorer" were:

1. The two-metre ring net of cheesecloth material for vertical hauls.
2. The one-metre ring nets also of cheesecloth for horizontal towing at surface, mid-water and bottom or intermediate lower strata to a depth of 100 metres. Duration of each haul fifteen minutes.
3. The Agassiz stramin net on a rectangular frame, also for horizontal towing at different depths. Duration of haul thirty minutes, comprising ten minutes at each depth.

Information regarding the fishing capacity of the different nets is given in the following table in which the stages are classed as follows: —

Stages 1, 1—2, 2 ..... Youngest
— 2—3, 3, 3—4, 4, 4—5, 5 .... Intermediate
— 5—6, 6 ..... Oldest

Table 1.

	Youngest	Intermediate	Oldest	Total	No. of Hauls May/Nov.	No. of Positive Hauls
2 m. chcl.	264	173	15	452	168	65
1 m. chcl. 0 m.....	11	12	6	29	161	9
— midwater or 50 m.	105	77	3	185	135	32
— bottom or 100 m.	275	252	13	540	161	51
Agassiz Stramin	77	253	59	389	114	49
Totals...	732	767	96	1595	739	206

According to the above table, the most productive net for lemon sole larvae was the deepest one-metre cheesecloth tow-net which was closely followed by the vertical two-metre cheesecloth. The Agassiz Stramin, which probably fishes slightly closer to the bottom than the deepest tow-net, caught a much smaller proportion of the earliest stages and a larger proportion of the oldest stages, than other nets.

Depth at which Larvae occur.

In order to determine the depth at which the larvae occur the one-metre tow-nets alone are considered. These nets are towed at surface, mid-water and bottom, but are not of the closing type so that positive results may have been obtained during hauling operations. The numbers at the different stages (Table 1) from each tow-net may be expressed as the following percentages:

	Youngest	Intermediate	Oldest	Totals
Surface	2.8	3.5	27.3	3.8
Midwater or 50 m.....	26.8	22.6	13.7	24.5
Bottom or 100 m.	70.4	73.9	59.0	71.7

These figures indicate that the bottom tow-net accounts for the largest percentage of the larvae. Percentages of the youngest and intermediate stages in each net are somewhat similar. In the case of the oldest larvae a much larger percentage is found in the surface net, but in view of the small numbers this point requires further investigation.

A further analysis of the tow-net catches according to the actual depth at which the nets are fishing is given in the following table.

Table 2.

	Youngest Stages		Intermediate Stages		Oldest Stages		Totals	
	No.	%	No.	%	No.	%	No.	%
Surface...	11	2.8	12	3.5	6	27.3	29	3.8
1— 30 m.	16	4.1	19	5.6	1	4.5	36	4.8
31— 70 m.	105	26.8	83	24.3	5	22.7	193	25.6
71—100 m.	259	66.3	227	66.6	10	45.5	496	65.8
Totals...	391		341		22		754	

Allowing for the fact that a number of larvae may be caught during the hauling of the mid-water and bottom nets, the evidence clearly shows that the bulk of the larvae is taken in the bottom tow-net at depths varying from 71—100 metres.

For depths of more than 100 metres the Agassiz Stramin net was used. It is unfortunate, however, that no collections referable to this depth only exist. It is noticeable, however, that hauls, in which part of the time was spent fishing deeper than 100 metres, produced relatively few larvae.

The capture of so few larvae at the surface has prompted a closer examination of the time of capture of these records, viz. Table 3.

Table 3.

Area	Date	Time of Day	Total	Youngest	Intermediate	Oldest
YY16d	4 June	11.20 p.m. to midnight.	2	1	1	—
A17a	8 —	12.10 a.m. to 2 a.m. ...	5	5	—	—
C15c	9 July	1 a.m. to 2·35 a.m..	15	4	11	—
A15d	17 Aug.	10.30 p.m. to 11·30 p.m.	1	—	—	1
B16c	18 —	4.20 a.m. to 5·15 a.m..	1	—	—	1
C16b	24 —	2.50 a.m. to 4·05 a.m..	1	—	—	1
E17b	8 Oct.	12.30 a.m. to 2 a.m. ...	1	—	—	1
D14a	8 —	10.30 p.m. to midnight.	2	—	—	2
B11d	1 Nov.	8.30 p.m. to 9·40 p.m..	1	1	—	—

In each case the larvae were caught during the hours of darkness which suggests the existence of an upward and downward movement of the larvae with darkness and daylight as characteristic of other species of fish and plankton generally, *vide* JOHANSEN (3) and RUSSELL (6).

The Occurrence of the Larvae.

he first lemon sole larvae were caught near the land Skerries, Copinsay and Fair Isle during the nd week of May. Of the thirty specimens taken hese places, twenty-eight were at Stage 1 or 2, e only two were beyond these stages of develop- t. Seven larvae taken west of Shetland showed same development.

he Faroe-Shetland Channel yielded no larvae and 'aroe only three specimens were taken, two of h were at Stage 1 and one at Stage 2. Investi- ons were carried out all round the islands and at e Bank, from May 17th to May 27th, so that meagre results would seem to indicate a later ning than in Scottish waters, especially since larvae were taken at Sulisker and twenty-five of the Butt of Lewis on May 28th, of which twenty-four were at Stages 1 and 2, while two mens were actually at Stage 6.

the first week of June a series of productive s of larvae was obtained on a line of stations Cape Wrath to Flugga in Shetland. Omitting hauls by the Agassiz Stramin (which was not at every station) and utilising only 2-metre cal and tow-net hauls for true comparison, the wing are the numbers and percentages of the e at the different stages.

Table 4.

		Development Stages 1 1-2 2	2-3 3 3-4	4 4-5 5	5-6 6
Sulisker	Nos.	23	40	12	1
Butt of Lewis	%	30·3	52·6	15·8	1·3
Sule Skerry	Nos.	61	35	12	—
Noup Head	%	56·5	32·4	11·1	—
North of	Nos.	83	41	3	—
Orkney	%	65·3	32·3	2·4	—
West of	Nos.	109	31	5	—
Shetland	%	75·2	21·4	3·4	—

is clear that proceeding northwards the percen- of the youngest stages increases, while that of older stages decreases. It may thus be concluded spawning is early in the region of St. Kilda, Flannan Isles, and the Butt of Lewis, and is in beginning towards the north-east. In the month larvae were scarce in east Shetland rs, but became more numerous immediately to east of the Moray Firth.

East Moray Firth, 12th June.

Stages	1 1-2 2	2-3 3 3-4	4 4-5 5	5-6 6	Totals
of Larvae	46	26	9	0	81
.....	56.8	32.1	11.1		
age No. of Larvae r Haul	6	3	1	—	10

These figures, in comparison with those of Table 4, resemble the figures for the Sule Skerry—Noup Head region, suggesting contemporaneous spawning.

Towards the end of June and in the first half of July operations were carried out mainly in the Central and Eastern Northern North Sea where records were scarce. Near Fair Isle, larvae were more numerous but the best catches on this cruise were taken in the Moray Firth, B15a, and east of that region, in C15, where the two most productive single hauls of the year were obtained. At the latter station the largest number of lemon sole larvae caught by one net per unit haul was recorded when 141 specimens were taken in the bottom tow-net. The following figures represent the outer Moray Firth (C16b, C15c) for July 8th to 9th.

Stages	1 1-2 2	2-3 3 3-4	4 4-5 5	5-6 6	Totals
Nos. of Larvae	76	82	13	2	173
%	43.9	47.4	7.5	1.2	
Average No. of Larvae per Haul ...	10	10	2		22

Although the percentage of younger stages is lower, the actual numbers of each stage taken per haul are higher in July than in June. In this month a slight concentration of larvae was also located off the Aberdeenshire coast. In the Firth of Forth, however, an intensive series of hauls failed to produce a single specimen.

As the monthly tables indicate, larvae were not so numerous in the collections from the beginning of August onwards. Results in this month demonstrate their widespread distribution, however, with concentrations off the Aberdeenshire coast and in the Moray Firth at Cullen Deep and even in the Dornoch Firth. At the latter station eight specimens of the youngest stages were taken in a total of fifteen; these were the only examples of the youngest stages taken in water of less than 25 metres' depth throughout the year.

Towards the end of September operations west of Shetland produced only a few larvae where previously in June they were present in considerable numbers.

The youngest stages of the larvae continued to appear in the catches throughout September and October over a wide area from outside the Firth of Forth northwards to Scalloway Deep and eastwards to the Fisher Bank. Hauls within the Firth of Forth were again blank. Out of twenty-nine larvae caught in November, eight were at Stage 2 or younger, which clearly indicates that spawning is continued into this month in the Central North Sea at any rate. The first records from the Firth of Forth were obtained when nine larvae were taken in the vicinity of the Isle of May.

Spawning Places.

The spawning grounds of lemon soles in the North Sea have already been traced generally by a study of the occurrence of ripe and newly spent fish (1). In order to gain corroborative evidence on this point a chart has been prepared to show the occurrence of the smallest larvae during each month of 1931. It is difficult to state the age of the larvae at the different stages. According to McIntosh (4) the yolk is completely absorbed after four days, which would place Stage 1 about this age. In any case Stages 1 and 2 will have drifted a comparatively short distance from the spawning grounds so that they alone have been included in drawing up the accompanying Chart.

The distribution of the larvae in 1931 confirms the view of the widespread spawning habit of the lemon sole. Certain areas, however, stand out as specially favoured by spawning fish.

1. The north-west coast area stretching from the Butt of Lewis to Flugga. From a consideration of both the size of the area and of the numbers of larvae found at each station, this region was the most important in the 1931 investigations.
2. Moray Firth, particularly statistical squares B15, C15 and C16. Although not so extensive as the former area, this area produced even richer hauls of larvae in July than the former did in June, for example, C15 gave rise to the largest collection from five hauls for any one station, namely, 193 larvae.
3. Off the Aberdeenshire coast.
4. The neighbourhood of Fair Isle.

At no time did the last two areas produce catches comparable with the first two, yet they were sufficiently rich to be distinguishable from the rest of the North Sea.

Table 5.

Development Stages.		Sulisker Butt of Lewis	North-West Coast	Aberdeen Coast Moray Firth	Aberdeen Coast Moray Firth	Aberdeen Coast Moray Firth	Aberdeen Coast Moray Firth
		May	June	June	July	August	September
1	No.	2	59	7	2	3	
	Range	5·5—6·0	4·5—6·5	4·5—6·0	5·5	5·0—5·5	
	Mean	5·8	5·7	5·4	5·5	5·2	
1—2	No.	7	105	28	58	17	3
	Range	6·5—8·0	6·0—8·5	6·0—8·0	5·5—8·5	5·5—7·5	5·5—7·5
	Mean	7·2	7·3	7·1	7·2	7·0	6·5
2	No.	15	98	33	88	38	10
	Range	8·0—9·0	6·5—10·0	7·5—9·5	7·0—9·5	7·0—9·5	6·0—8·5
	Mean	8·5	8·5	8·6	8·5	8·2	7·5
2—3	No.	4	42	18	62	18	
	Range	8·5—9·0	8·5—10·5	8·5—10·5	8·0—10·5	8·0—10·5	
	Mean	8·9	9·5	9·6	9·3	9·1	
3	No.	31	48	18	91	27	4
	Range	9·5—12·0	9·0—12·0	10·0—12·0	8·0—11·5	8·5—11·5	8·0—9·5
	Mean	10·3	10·6	10·6	10·0	9·9	8·6
3—4	No.	9	28	16	36	9	7
	Range	10·5—12·5	10·0—12·5	9·5—13·5	8·5—12·5	10·0—11·5	9·0—10·0
	Mean	11·6	11·4	11·8	10·8	10·8	9·6
4	No.	6	24	9	32	10	19
	Range	11·5—13·5	11·5—14·5	11·5—13·5	11·0—14·0	10·0—13·0	8·0—12·0
	Mean	12·6	12·9	12·7	12·1	11·8	10·3
4—5	No.	8	8	11	4	7	11
	Range	12·5—15·5	12·5—15·0	11·5—15·5	13·0—14·5	10·5—13·5	10·0—12·0
	Mean	13·8	13·9	13·9	13·6	12·3	11·4
5	No.		5	7	7	3	12
	Range		13·5—16·0	13·0—16·0	14·5—17·5	10·5—14·0	10·5—14·0
	Mean		15·1	15·3	15·3	11·8	12·0
5—6	No.			2	6	7	7
	Range			15·0—16·5	15·5—17·0	12·5—15·5	12·5—15·0
	Mean			15·8	16·3	13·9	13·5
6	No.	2		1	7	12	29
	Range	18·0—18·5		18·5	17·5—23·5	15·0—23·0	12·5—25·0
	Mean	18·3		18·5	19·9	18·7	16·9

Table 6.

Larval Lemon Soles 1931.

Date	Locality	No. of Hauls	No. of Larvae	Developmental Stages 1	1—2	2	2—3	3	3—4	4	4—5	5	5—6	6
10 May	Inner Moray F.	13	—	..	..	..	..	..	..	..	..	..	..	..
11 „	E. Orkney—Fair Isle	15	30	2	16	10	1	1	..	..	..	..	..	..
16 „	West Shetland	13	7	—	3	2	1	1	..	..	..	..	..	..
17 „	Faroe—Faroe Bk...	40	3	2	—	1	..	..	..	..	..	..	..	..
„	Butt of Lewis.....	9	85	2	7	15	4	31	9	6	8	1	—	2
			125	6	26	28	6	33	9	6	8	1	—	2
4 June	N. Minch.....	6	10	—	1	1	—	3	1	2	2	..	..	..
7 „	Sule Skerry	4	51	10	9	9	5	9	2	5	2	..	..	..
8 „	Noup Hd.	5	85	15	15	10	5	7	14	12	5	2	..	..
8 „	North Orkney.....	4	127	2	40	41	19	16	6	3	..	..	..	..
8 „	Foula.....	5	49	5	20	12	3	6	—	1	1	1	..	..
9 „	Ronas Voe Grd....	5	69	18	11	18	8	6	4	3	—	1	..	..
10 „	Flugga.....	5	36	9	10	8	2	4	2	..	..	..	..	..
12 „	East Shetland.....	17	36	1	3	9	4	10	3	2	3	1	..	..
12 „	Outer Moray F.	9	86	5	20	22	10	10	9	4	3	3	..	..
13 „	Aberdeenshire Coast	11	64	2	8	11	8	8	7	5	8	4	2	1
19 „	Northern N. Sea...	40	11	1	5	3	1	—	—	1	..	..	..	..
19 „	Fair Isle.....	5	32	7	7	10	4	2	1	1	..	..	..	..
			656	75	149	154	69	81	49	39	24	12	2	1
4 July	Northern N. Sea...	25	19	—	3	5	—	3	3	—	1	3	—	1
5 „	East Shetland.....	2	8	1	5	2	..	..	..	..	..	..	..	..
7 „	Fair Isle.....	17	43	4	12	15	2	4	2	1	1	2	..	..
8 „	Moray F. (B 15a) ..	5	128	—	10	28	17	34	14	13	—	5	4	3
9 „	Outer Moray F.	11	222	1	44	46	32	51	20	16	4	2	2	4
0 „	Aberdeenshire C....	15	59	1	5	21	14	8	4	4	—	—	2	..
6 „	Firth of Forth	28	—	..	..	..	..	..	..	..	..	..	..	..
			479	7	79	117	65	100	43	34	6	12	8	8
0 Aug.	Aberdeenshire C....	29	39	1	6	8	4	5	3	3	2	2	1	4
7 „	Central N. Sea.....	35	23	—	4	9	3	3	—	2	—	—	1	1
5 „	Central N. Sea.....	26	7	—	—	—	—	2	1	—	2	2	—	—
8 „	Moray Firth	21	81	2	7	23	12	17	3	7	3	3	1	3
4 „	Fair Isle.....	16	14	—	—	—	—	—	2	—	3	—	5	4
4 „	Northern N. Sea...	14	5	—	—	1	—	1	1	—	—	—	—	2
			169	3	17	41	19	28	10	12	10	7	8	14
3 Sept.	Firth of Forth	21	—	..	..	..	..	..	..	..	..	..	..	..
7 „	Central N. Sea.....	45	52	—	3	11	2	2	6	10	7	5	3	3
1 „	Aberdeenshire C....	20	33	—	3	2	—	2	1	8	3	8	2	4
2 „	Outer Moray F.	10	3	—	—	—	1	—	1	1	—	—	—	—
4 „	Moray Firth	21	30	—	—	1	—	1	—	1	1	1	2	23
6 „	West Orkney.....	20	10	—	—	—	1	1	—	1	—	1	2	4
9 „	E. Orkney—Fair Isle	10	1	—	—	—	—	—	—	—	—	—	—	1
0 „	West Shetland	20	5	—	1	1	—	—	—	—	1	—	—	2
0 „	East Shetland.....	10	—	..	..	..	..	..	..	..	..	..	..	..
			134	—	7	15	4	6	8	21	12	15	9	37
8 Oct.	North Sea	19	3	—	—	—	—	—	—	—	—	—	1	2
1 Nov.	Firth of Forth	5	9	—	—	1	1	1	—	2	2	1	1	—
7 „	Central N. Sea.....	56	20	—	1	6	3	3	2	2	—	—	2	1
4 „	Aberdeenshire C....	5	—	..	..	..	..	..	..	..	..	..	..	..
			29	—	1	7	4	4	2	4	2	1	3	1

These results support the conclusion formed from a study of ripe and newly spent fish in so far as they point out the widespread spawning habit of the species with concentrations at various points off the Scottish coast. They also, however, demonstrate the presence of important spawning grounds on the north-west coast grounds of which little indication was given by the ripe and spent fish, which latter was due no doubt to paucity of records from that region. Further information, however, is desirable on these points.

Measurements of Larvae.

The larvae were measured to the nearest half millimetre. No variation in the sizes of the stages was observed in different areas in the same month. In June, for example, average sizes for each stage at localities so far apart as Sule Skerry, Flugga, East of the Moray Firth and off the Aberdeenshire coast were almost identical.

From July onwards records are almost wholly from the North Sea proper and particularly from the Moray Firth and Aberdeenshire coast waters. Average sizes have been calculated from these combined regions for each month.

The results (Table 5) are interesting in that they show a steady decline in the average size of each stage, first noticeable in the July figures and continuing to September after which records are too scanty to give reliable figures.

This may signify either of two things: —

1. That larval growth towards the end of the year becomes slower, or
2. That development through the different stages is speeded up relative to the rate of growth.

As regards several of the points discussed in this paper, it is necessary to acquire fuller information before conclusions can be drawn, and it is intended therefore to continue the work over several other years.

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10.

minary Observations on the Food of the Plaice *(Pleuronectes platessa)* in Scottish Waters.

By

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e investigations in Scottish waters have been centrated, in recent years, on the bays of t coast and have been concerned mainly with blems of growth and recruitment of the stocks. nas also been conducted on the food of that and stomachs have been collected and ed from an extensive part of the coast be- Dornoch Firth, at the head of the Moray Firth, e Firth of Forth.

neral indication of the nature of the food in t localities within that extent of coast is now le, while the data for Aberdeen and St. An- Bays are sufficiently comprehensive to permit e detailed observations.

present report is a preliminary one since investigation is necessary in order to obtain e knowledge of the feeding conditions through- area. It is also intended to extend the in- ions to the elucidation of the relationship the plaice food and the fauna of the bays.

ds.

naterial for the survey was collected during wling cruises of the Inshore Research Vessel Fishery Board for Scotland. Each catch of after measurement and extraction of otoliths, ted into five-centimetre groups, except fish 1 cm. in length, which constituted one group. sentative sample of stomachs was then coll- om each size-group and preserved for exami- n the Laboratory. The details of the records xamination show the frequencies of occurrence food animal in the stomachs, while an esti- of the amount of food consumed at the time ure was obtained by the volumetric measure- ment of the stomach contents by water displacement. The volumes of the different animal groups were recorded separately.

Nature of Grounds Surveyed.

The knowledge we have concerning the fauna of the grounds surveyed is derived from Steven's[1]) work. This is confined to the Echinodermata and Mollusca, and will have to be supplemented by detailed observations on all the animal groups.

The beaches along the bays inhabited by young plaice are recorded by Stephen as being of two kinds, namely: (a) sandy beaches and (b) beaches in which the sand is mixed with mud. These beaches are inhabited by a number of characteristic molluscs such as *Macoma baltica*, *Cardium edule*, *Tellina tenuis* and *Paludestrina stagnalis*, the distribution of which does not extend further out than the two-fathom line (L.W.M.). The lamellibranch *Donax vittatus* is sometimes associated with these; there is normally a dense population of this species in St. Andrews Bay, extending as far out as the five-fathom line.

Along the coast, the fauna beyond the two-fathom line is characterised by the presence of two different types of lamellibranchs according to the nature of the bottom, whether it consists of sand or mud. The muddy grounds are the richer of the two, and their molluscan fauna is marked by the predominance of the genus Abra (Syndosmya). The grounds off Munlochy Bay in Inverness Firth and certain areas within the Firth of Forth come within this category as do parts of the outer reaches of St. Andrews Bay.

[1]) Trans. Roy. Soc. of Edinburgh, Vol. LVII, Pt. III (Nos. 22 and 32), 1932—1933.

Table I. Moray Firth.

Percentage Frequencies of Different Food Animals in Stomachs Containing Respective Animal Groups.

	Munlochy Bay	Nairn Bay	Burghead Bay	Dornoch Firth	Spey Bay	Cullen Bay	Banff Bay	Sandend Bay	Gardens-town Bay	Aber-dour Bay
Amphiura chiajei										
— *filiformis* ...	—	90	96	100	—	—	—	—	* 3 st.	2 st
Ophiura sp.	—	10	4	6	—	—	—	—	—	4 st
Portunus sp.....	—	—	89	—	12	—	—	—	—	—
Crangon sp.	—	—	12	—	6	—	—	—	—	—
Ampelisca sp.....	—	—	—	89	—	—	—	—	—	—
Leucon sp.	—	—	—	—	65	—	—	—	—	—
Diastylis rathkei	—	—	—	—	—	—	—	—	—	—
Ammotrypane aulogaster	62	—	—	—	—	—	—	—	—	—
Nephthys sp.	27	28	23	50	29	73	40	100	27	87
Goniada maculata	0·5	6	0·6	23	—	—	—	—	—	3
Lagis koreni.....	8	5	0·6	6	—	—	—	—	7	—
Stylaroides sp.	0·5	—	—	—	—	—	—	—	—	—
Phyllodoce sp.	2	21	8	3	21	4	—	—	7	17
Aphrodite sp.	—	—	—	—	—	—	—	—	—	—
Lanice conchilega.....	—	40	59	6	6	4	20	—	—	—
Arenicola marina.....	—	2	6	49	49	35	40	—	—	10
Glycera sp.	—	—	1	—	—	—	—	—	—	—
Abra alba	100	—	—	—	—	—	—	—	—	—
Tellina fabula	—	—	—	37	—	—	—	—	54	29
Solen sp.....	1	56	18	52	—	—	—	—	—	—
Mactra stultorum.....	—	—	—	4	—	—	—	—	—	—
— *solida*.....	—	—	—	7	—	—	—	—	—	—
Donax vittatus	—	—	—	11	—	4 st.	4 st.	100	46	79
Siphons (Molluscs)	—	38	88	—	97	—	—	—	—	—

* st. = Stomachs.

Table II. Aberdeen Bay.

(a) Relative Volumes of each Animal Group per 100 Fish.

	cm. < 11					11—15				16—20				21—25				26—30			
*)	C	A	M	F	Total	A	M	F	Total	A	M	F	Total	A	M	F	Total	A	M	F	Total
2—4 fms.....	0·5	5·5	0·5	—	**6·5**	18	—	14	**32**	23	—	92	**115**	48	—	95	**143**	57	—	150	207
6—8 —	—	—	—	—	—	41	—	9	**50**	64	2	8	**74**	67	—	9	**76**	141	3	30	174
> 8 —	—	—	—	—	—	—	—	—	—	52	—	—	**52**	74	—	—	**74**	85	—	4	89

(b) Percentage Frequencies of Common Food Animals in Stomachs containing Each Animal Group.

	Nephthys sp.			*Goniada maculata*			*Arenicola marina*			*Lanice conchilega*			Young Polychaeta			*Tellina fabula*			*Ammodytes* sp.		
Size-Group Fms.	2-4	4-8	> 8	2-4	4-8	> 8	2-4	4-8	> 8	2-4	4-8	> 8	2-4	4-8	> 8	2-4	4-8	> 8	2-4	4-8	> 8
< 11 cm.	17	16	—	—	16	—	28	—	—	—	9	—	39	55	—	—	—	—	—	—	—
11—15 -	12	29	—	3	—	—	73	71	—	2	7	—	5	—	—	—	—	—	100	100	—
16—20 -	9	32	70	—	3	—	84	51	—	7	17	35	—	—	—	—	100	—	100	100	—
21—25 -	12	57	62	2	4	5	75	27	—	13	21	36	—	—	—	—	100	—	100	100	—
26—30 -	2	37	51	—	3	3	92	20	3	11	48	52	—	—	—	—	100	—	100	100	—

*) E, C, A, M, F, denote Echinodermata, Crustacea, Annelida, Mollusca and Fish.

ne predominating molluscan species on the sandy nds are *Tellina fabula* and *Nucula nitida*, while characteristic Echinoderms are *Ophiura albida* *O. texturata*.

Moray Firth.

ne hundred and four size-group samples were nined from the following localities within the y Firth: Inverness Firth (off Munlochy Bay), n Bay, Dornoch Firth, Burghead Bay, Spey Cullen Bay, Gardenstown Bay, Sandend Bay, ff Bay and Aberdour Bay.

bout 80 % of the material for the Moray Firth ngs to the first four of the above localities. These part of the plaice nursery situated at the head e Firth and are normally more densely populated the others which are situated along its southern . The following table shows for each size-group elative volumes (c. c.) per 100 fish of the different al classes that constituted the food:—

	Echino-dermata	Crustacea	Annelida	Mollusca	Fish
rness Firth					
< 11 cm....	—	—	2	—	—
1—15 - ...	—	—	2·5	2·5	—
6—20 - ...	—	—	4	8	—
1—25 - ...	—	—	4	14·5	—
6—30 - ...	—	—	9	23	—
n Bay					
< 11 cm....	0·5	—	0·5	—	—
1—15 - ...	0·5	—	4	5	—
6—20 - ...	2	—	11	2	4
1—25 - ...	5	—	31	—	—
6—30 - ...	3	—	24	—	5
och Firth					
1—15 cm....	3	—	8	—	—
6—20 - ...	1	—	21	—	—
—25 - ...	0·5	—	31	2·5	—
6—30 - ...	—	2·5	38	4·5	—
head Bay					
—15 cm....	—	—	5	2·5	2·5
6—20 - ...	1·5	—	1·5	4	6
—25 - ...	3	—	9	4	9·5
6—30 - ...	2	2	29	2·5	14
—35 - ...	—	—	2	—	76

e size-group sample of fish under 11 cm. in n was examined from the Inverness Firth, the ach contents of which consisted wholly of lida. Fish above 11 cm. which constitute the er part of the plaice population feed also on sca. Undoubted preference for the latter is it d during the latter months of the year, since omprised from 72 to 100 per cent. of the stomach nts for October and November.

ble I shows, for the localities within the Moray the percentage frequencies of the different food ls in stomachs containing the respective animal s. It is apparent therefrom, that off Munlochy concentration is directed to the exploitation of a limited number of food animals, there being three principal species. Two of these are the Polychaeta, *Ammotrypane aulogaster* and *Nephthys* sp. which occurred respectively in 62 per cent. and 27 per cent. of the stomachs containing Annelida. *Syndosmya alba*, which is a characteristic inhabitant of this area, is practically the only mollusc eaten.

(Table I, see p. 50.)

Annelida are an important source of food for plaice in Nairn Bay and Dornoch Firth, where they constituted 73 per cent. and 87 per cent. of the stomach contents of all sizes examined. Echinodermata, Mollusca and fish, the latter in the form of sandeels, may also be eaten, Mollusca having a high relative value in the smaller fish in Nairn Bay.

The intensive consumption of Annelida also extends to Burghead Bay, where they are preferred to all other forms in the early part of the year. During the summer and autumn months, however, Echinodermata, Mollusca and fish (sandeels), all appear regularly in the stomachs, sandeels being the prominent feature of the diet of fish above 30 cm. in length.

The texture of the sea floor in the above three localities consists chiefly of sand, in which respect it differs from the grounds off Munlochy Bay, where the deposit is mud. There is, accordingly, a difference in the nature of the food animals normally consumed by the plaice. Several annelid species appear in the data, *Lanice conchilega* and *Nephthys* sp. being noteworthy for their widespread importance, while the chief Echinoderm is *Amphiura* sp. The minor feeding on Crustacea consists of *Portunus* sp. (juv.), *Crangon* sp. (juv.) or the amphipod *Ampelisca* sp., the consumption of the first two species being confined to the autumn months. A greater variety of molluscan species appears in the data for Dornoch Firth than for Nairn and Burghead Bays, but *Cultellus pellucidus* is common to all three. In the latter two bays, the plaice have also been found to nip off the siphons of small lamellibranchs, the species of which have not as yet been identified.

The following table shows the relative volumes per 100 fish for each size group of the types of animals that constitute the food in the bays east of Burghead Bay — i. e., Spey Bay to Aberdour Bay:—

	Annelida	Mollusca	Fish
Spey Bay			
< 11 cm.....	1	—	—
11—15 -	8	6	—
16—20 -	7·5	3·5	—
21—25 -	11·5	4	18·5
26—30 -	26	3	15·5
Cullen Bay			
11—15 cm.....	12	6	—
16—20 -	31	—	—
21—25 -	31	—	23
Banff Bay			
21—25 cm.....	17	—	—
26—30 -	25	8	67
31—35 -	—	—	186

	Annelida	Mollusca	Fish
Sandend Bay			
11—15 cm.	2·5	10	—
16—20 -	13	27	13
21—25 -	14	9	34
26—30 -	—	—	84
Gardenstown Bay			
16—20 cm.	8	—	115
21—25 -	5	5	164
26—30 -	16	18	210
31—35 -	16	—	280
Aberdour Bay			
16—20 cm.	12	12	—
21—25 -	6	9	84
26—30 -	37	31	94
31—35 -	5	15	210

The plaice in these localities feed on Annelida, Mollusca and fish (sandeels), the latter item being most prominent in the stomachs of the larger fish.

The species exploited are representative of several of the forms common to Dornoch Firth, Nairn Bay and Burghead Bay, *Nephthys* sp. and the siphons of small molluscs being examples. The attacking of lugworm (*Arenicola marina*) by nipping off certain of the tail segments, shown by Blegvad[1]) to occur frequently in Danish waters, is also a common habit of the plaice in Scottish waters. There is evidence of it in several of the sandy bays of the Moray Firth, particularly in Spey Bay, Cullen Bay and Banff Bay.

The Polychaete *Megalone papillicornis* is peculiar to the food in Gardenstown Bay and has been similarly recorded in Scottish waters.

East Coast Bight.

Aberdeen Bay. The data for Aberdeen Bay were collected from the following positions:—

Bathing Station to North of Don Mouth 2—4 fathoms
Bathing Station to North of Don Mouth 4—8 fathoms
Off Black Dog ..... > 8 fathoms

Altogether one hundred samples containing 2517 fish were examined for the period May to September, so that the results are representative of the feeding conditions during the principal growth period of the year.

Table II shows (a) the relative volumes of each animal group per 100 fish of food for each size-group of plaice, and (b) percentage frequencies of food animals in stomachs containing respective animal groups.

(Table II, see p. 50.)

The records for the very young plaice (< 11 cm.) were collected from the shallow depths which are the normal habitat of these small fish and were found to feed principally on young Polychaeta. The only occasion when slight departure from that type of feeding occurred was when spasmodic specimens of amphipods and young razor shells (Ensis) were eaten.

Adult Polychaeta play a big part in the food of all other sizes of plaice in the Bay but the older and larger fish which frequent depths within the four-fathom line also feed voraciously on sandeels. Polychaeta are the chief source beyond the four-fathom line since the consumption of sandeels is much reduced between 4 and 8 fathoms and ceases altogether beyond the latter depth. Mollusca occur very infrequently in the stomachs, the species then taken being *Tellina fabula*.

Altogether twenty-four genera or species were found in the stomachs but the spasmodic appearance of several of these renders them unimportant as food. An examination of the frequencies of occurrence of more common forms shows that the diet is confined to a limited number of species, all of which are found to be important in other sandy bays along the coast.

Table II (b) indicates that the variation in the relative importance of annelid food in different part of the bay is accompanied by changes in the principal species exploited. The young plaice (< 11 cm.) feed chiefly on young Polychaetes in depths up to 4 fathoms but a few also partake of adult *Nephthys* sp. and the hinder parts of *Arenicola marina*. *Arenicola* is by far the most important Polychaete for all other sizes inhabiting these depths, having percentage frequencies in the different size groups ranging from 73 to 92. Farther out — depth 4 to 8 fathoms — three species constitute the bulk of the food, namely, *Lanice conchilega*, *Nephthys* sp. and *Arenicola marina*. *Arenicola* is most important in the 11—20 cm. groups but fish above 20 cm. concentrate more on *Lanice* and *Nephthys*. In depths beyond 8 fathoms *Arenicola* drops out of the food cycle altogether and the plaice live chiefly on *Lanice* and *Nephthys*.

Lunan Bay. The results from Lunan Bay are derived from the examination of 31 size-group samples containing 730 fish; the following are the average relative volumes of the individual animal groups per 100 fish:—

cm. 11-15				16-20					21—25				26-30			
E	C	A	M	E	C	A	M	F	E	A	M	F	C	A	M	F
2·5	0·5	6·5	2	1·5	1	8·5	7	7·5	1	10	7·5	12	1	8	19	17

No data are as yet available for plaice under 11 cm. in length, but the food of fish above that size consists of Echinodermata, Crustacea, Annelida, Mollusca and fish. Crustacea occur frequently in the stomachs but are never eaten in quantity. The smaller plaice (11—15 cm. group) feed principally on Annelida, and less abundantly on Echinodermata and Mollusca. The volumes of Echinodermata relative to those of other animal groups in fish above 15 cm. in length are small, since these sizes concentrate on the exploitation of Annelida, Mollusca and fish.

[1]) Report Danish Biol. Stat. Vol. XXXVI, Part 1, 1930.

he following table shows the percentage frequen- of the different food animals in the stomachs taining each animal group:—

Echinodermata	
iura albida	90
iura texturata	—
phiura chiajei	6
phiura filiformis	—
Crustacea	
tunus sp. juv.	51
ystes cassivelaunus juv.	2
ngon sp. juv.	2
pelisca sp.	20
stylis rathkei	47
Annelida	
us koreni	11
lthys sp.	77
llodoce sp.	4
nicola marina	3
motrypane aulogaster	1
iada maculata	12
ice conchilega	1
Molluscs	
ula nitida	64
s ensis	32
ellus pellucidus	2
na fabula	19
us gallina	1
Fish	
nodytes sp.	100

ohiura albida and *O. texturata* are characteristic bitants of bays where sand predominates in the ure of the bottom, of which Lunan Bay is an nple.

oung specimens of *Portunus* sp. sometimes occur he stomachs during the autumn months, but at r seasons the minor feeding on Crustacea con- of the Amphipoda *Ampelisca* sp. and the Cuma- *Diastylis rathkei*.

he Annelid food consists chiefly of *Nephthys* sp. h occurred in the stomachs much more fre- tly than any other species.

he bay normally sustains an extensive population *Nucula nitida* which is frequently associated in stomachs with young specimens of *Ensis ensis*, e sandeels again constitute the entire fish food.

arnoustie Bay. The data from Carnoustie Bay imited to the results of the examination of 192 achs belonging to four samples collected in h. They are useful in indicating the nature of laice food there, the following being the species: —

Ophiura albida	*Arenicola marina*
O. texturata	*Phyllodoce* sp.
Amphiura sp.	*Tellina fabula*
Goniada maculata	*Ensis ensis*
Nephthys sp.	*Curtellus pellucidus*

St. Andrews Bay. St. Andrews Bay has been surveyed in the following four positions:—

Position D — Between St. Andrews Harbour and River Eden	2—4	fathoms
Position C — 56°25′ N. 2°40′ W. to 56°24′ N. 2°43′ W.	4—6	—
Position B — 56°23′ N. 2°44′ W. to 56°21′ N. 2°43′ W.	6—8	—
Position A — 56°23′ N. 2°39′ W. to 56°25′ N. 2°39′ W.	9—10	—

Table III is similar to that for Aberdeen Bay and shows for St. Andrews Bay (a) the relative volumes of the various animal groups per 100 fish from all the samples examined and (b) the percentage frequencies of the various food animals in the stomachs containing each animal group.

The above records, when compared with those of Aberdeen Bay point to the consumption of a wider variety of food in St. Andrews Bay, Crustacea and Mollusca as well as Annelida and fish being important items. Echinodermata occasionally appeared in the stomachs, when isolated specimens of *Ophiura* (*O. albida* and *O. texturata*) were eaten.

The small plaice (< 11 cm.) feed on Crustacea as well as Annelida and not solely on the latter as in Aberdeen Bay. Even when these small fish move to the deeper parts of the bay their diet remains the same, as evidenced by the data for Positions B, C and A.

Crustacea continue to appear in small quantities in the stomachs of fish between 11 cm. and 15 cm. in length, but these and the larger fish feed chiefly on Annelids, Mollusca and fish whilst frequenting the grounds in the vicinity of Positions D, C and B. Further out in the deeper water of Position A, fish cease to be an item of diet which consists wholly on Annelida and Mollusca.

The data of species demonstrate more clearly the relatively wide variety of feeding that prevails in St. Andrews Bay. A large number of species, 45 in all, were found in the stomachs but, as in Aberdeen Bay, several of these are unimportant owing to the paucity of their occurrence in the stomachs and do not appear in the table.

The Crustacea consist principally of the Amphipod *Ampelisca* sp. and the Cumacean *Leucon nasicus*.

The Annelid diet of the small plaice is made up of young Nemertea and young Polychaeta, both of which are also eaten fairly regularly by members of the 11—15 cm. size-group. The three adult Polychaeta *Arenicola marina*, *Nephthys* sp. and *Lanice conchilega* which constitute the main annelid food

Table III. St. Andrews Bay.

(a) Relative Volumes of each Animal Group per 100 Fish.

	cm. < 11			11—15					16—20				21—25				26—30			
	C	A	Total	C	A	M	F	Total	A	M	F	Total	A	M	F	Total	A	M	F	Total
Position D. 2—4 fms.	0·5	2	**2·5**	—	13	7	2	**22**	21	13	19	**53**	23	22	24	**79**	—	—	—	—
— C. 4—6 -	1	2	**3**	—	8	7	8	**23**	13	7	22	**42**	12	10	41	**63**	—	—	—	—
— B. 6—8 -	3	2	**5**	0·5	7	6	0·5	**14**	24	6	18	**48**	32	8	21	**61**	57	16	20	**93**
— A. 9—10 -	1·5	1·5	**3**	0·5	4	4	—	**8·5**	12	14	—	**26**	20	23	—	**43**	32	54	—	**86**

(b) Percentage Frequencies of Food Animals in Stomachs containing Respective Animal Groups.

	Ampelisca sp.	*Leucon nasicus*	*Phyllodoce groenlandica*	*Nephthys* sp.	*Arenicola marina*	*Goniada maculata*	*Lagis koreni*	*Lanice conchilega*	*Polychaeta* juv.	*Nemertea* juv.	*Tellina fabula*	*Abra alba*	*Nucula nitida*	*Donax vittatus*	*Montacuta ferruginosa*	*Ensis ensis* juv.	*Ammodytes* sp.
Position D. < 11 cm. . . .	68	30	—	—	—	—	—	—	32	85	—	—	—	—	—	—	—
11—15 - . . .	—	—	—	4	15	4	6	67	10	—	14	—	—	82	10	4	100
16—20 - . . .	—	—	8	18	15	4	5	58	4	—	7	—	—	87	12	2	100
21—25 - . . .	—	—	1	8	13	8	4	67	3	—	5	—	—	96	10	—	100
26—30 - . . .	—	—	—	23	32	6	7	43	—	—	—	—	—	100	—	—	100
Position C. < 11 cm.	72	29	—	7	3	3	—	3	88	—	—	—	—	—	—	—	—
11—15 - . . .	—	—	—	32	16	22	5	10	25	—	92	17	2	—	—	4	100
16—20 - . . .	—	—	3	15	48	15	3	21	3	—	100	2	—	2	—	4	100
21—25 - . . .	—	—	6	21	39	12	9	18	6	—	98	8	—	2	—	8	100
26—30 - . . .	—	—	9	14	22	4	3	52	—	—	100	—	—	—	—	—	100
Position B. < 11 cm.	57	39	2	3	—	—	—	—	56	67	—	—	—	—	—	—	—
11—15 - . . .	100	—	5	14	7	7	2	32	48	—	91	5	—	—	—	9	100
16—20 - . . .	—	—	21	17	31	6	12	36	—	—	88	16	—	—	—	7	100
21—25 - . . .	—	—	31	12	25	12	18	29	—	—	82	31	—	—	—	3	100
26—30 - . . .	—	—	22	16	14	4	19	46	—	—	89	12	—	—	—	—	100
Position A. < 11 cm.	43	67	—	21	—	—	—	—	33	59	—	—	—	—	—	—	—
11—15 - . . .	72	37	6	37	15	15	5	5	24	—	—	100	—	—	—	—	—
16—20 - . . .	—	—	3	17	46	22	19	—	11	—	—	92	14	—	—	12	—
21—25 - . . .	—	—	6	4	63	11	29	—	—	—	—	89	21	—	—	6	—
26—30 - . . .	—	—	7	10	14	14	67	—	—	—	—	95	26	—	—	—	—

in Aberdeen Bay are also an important source of nourishment in St. Andrews Bay. They are eaten in varying quantities by different sizes of fish and in different parts of the bay, but their populations do not appear to satisfy food requirements for such other forms as *Phyllodoce* sp., *Goniada maculata* and *Lagis koreni* are also readily consumed by the plaice.

Over an extensive part of the bay the molluscan food consists primarily of *Tellina fabula*; in the shallow waters near the shore, however, the plaice feed abundantly on *Donax vittatus*, while those inhabiting the muddy grounds in the deeper water concentrate on *Abra nitida*.

Firth of Forth.

The data for the Firth of Forth belong solely to the month of September and are derived from the examination of 36 size-group samples containing 865 stomachs collected from the following localities:— Kirkcaldy Bay, Largo Bay, Inchkeith, May Island, Bass Rock and Aberlady Bay.

Table IV gives (a) relative volumes of the different animal groups for each size group of plaice examined and also (b) the percentage frequencies of the various food animals in the stomachs.

The sea-floor of the Firth consists mainly of sand and mud but there are areas of pure sand in the shallow parts of such bays as Largo Bay and Aberlady Bay.

The exploitation of the different animal groups varies a good deal in the localities surveyed, but Annelida are consumed over a wider area than any other group. The plaice in the vicinity of Bass Rock, May Island and Inchkeith feed almost wholly on that form. Mollusca and Tunicata are also important in Kirkcaldy Bay, while in Largo and Aberlady Bays the plaice in September concentrate more on sandeels than on any other species.

Table IV. Firth of Forth.

(a) Relative Volumes of each Animal Group per 100 Fish.

cm.	< 11		11—15				16—20		21—25					26—30				31—35					36—40					
	C	M	C	A	M	F	A	F	E	C	A	M	F	A	M	T*	F	E	A	M	T*	F	E	C	A	M	T*	F
aldy. Bay	—	—	—	—	—	—	—	—	2	2	16·5	10	—	25	3	10	2	6	42	3	6	6	10	—	15	19	17	—
Bay ...	2	—	3	4	1	9	4	51	—	—	3	3	64	4	3	—	73	—	8	4	—	80	6	2	21	34	—	100
Keith...	—	—	—	—	—	—	—	—	—	—	—	—	—	133	—	—	—	—	131	10	—	—	—	—	309	—	—	—
Island...	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—	6	—	—	—	—	—	7	—	—	—
Rock ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	7	—	—	—
ady Bay.	1	1	—	13	—	5	2	29	—	—	14	—	105	69	—	—	110	—	—	—	—	—	—	—	—	—	—	—

nicata.

Percentage Frequencies of Food Animals in Stomachs containing Each Animal Group.

	Kirkcaldy Bay	Largo Bay	Inch Keith	May Island	Bass Rock	Aberlady Bay
ra albida	8	54	—	—	—	—
texturata	—	—	—	—	—	—
iura chiajei	95	38	—	—	—	—
filiformis	—	—	—	—	—	—
agurus sp.	—	3	—	—	—	—
nus sp.	92	1	—	—	—	6
n nasicus	8	61	—	—	—	56
elisca sp.	8	43	—	—	—	28
cola marina	—	13	—	—	—	—
hys sp.	9	40	4	—	—	25
koreni	32	7	2	* 3 st.	—	8
doce sp.	—	6	—	—	—	2
a sp.	7	6	21	5 st.	5 st.	9
da maculata	11	8	2	—	—	—
ellides stroemi	—	10	66	—	—	6
na elizabethae	39	1	4	—	—	29
dite sp.	2	1	4	—	—	—
otrypane aulogaster	30	1	28	2 st.	2 st.	16
s virens	1	—	2	—	—	2
itrite sp.	1	—	—	1 st.	—	—
e conchilega	2	—	—	3 st.	3 st.	8
ulus caudatus	9	1	6	—	1 st.	3
a stultorum	2	—	—	—	—	—
e sp.	4	—	—	—	—	—
lus pellucidus	—	80	—	—	—	—
alba	26	8	10 st.	—	—	5 st.
a sp.	2	2	—	—	—	—
a fabula	—	2	—	—	—	—
acuta sp.	—	2	—	—	—	—
sp.	21	—	—	—	—	1
um sp.	46	—	—	—	—	—
odytes sp.	100	100	—	—	—	—

. = Stomachs.

data of species show that there is considerable rn ity in the types of Annelida consumed in al parts of the Firth, the Gephyrean, *Priapulus tus* being important as well as the following haeta, *Nephthys* sp., *Ammotrypane aulogaster*, *koreni*, *Glycera lapidum*, *Goniada maculata*, *ellides stroemi* and *Melinna* sp.

e consumption of Tunicata in Kirkcaldy Bay to the presence there of an extensive population *lenaia corrugata*.

Food and Growth.

The plaice investigations have disclosed the fact that the members of that species which inhabit Aberdeen Bay grow at a rate greater than those of St. Andrews Bay. Both localities are included in an area of the Scottish east coast where seine-netting is permitted within the territorial zone. As the direct result of greater growth the plaice in Aberdeen Bay reach the commercial size more rapidly than in St.

Andrews Bay. This is made abundantly clear in the 32nd *Annual Report of the Fishery Board for Scotland* in which it is shown that, whereas 45 per cent. of the 1931 brood in Aberdeen Bay reached marketable size by October 1933, only 6·3 per cent. of the same class in St. Andrews Bay had reached the same stage by September of the same year.

An explanation of these differences in growth cannot be offered until the problem is approached conjointly from the biochemical, hydrographical, as well as the biological point of view. Certain facts support the importance of the biological view.

The following table gives the frequencies of different size-groups of plaice caught per ten hours' fishing in each of the bays since 1931, and allowing for annual fluctuations in brood productivity, the data therein give a comparative representation of the average populations in the respective localities in any one year.

	cm. < 11	11—15	16—20	21—25	26—30	> 30	Total
Aberdeen Bay: 2—4 fms.	1165	852	339	234	117	31	2738
— 4—8 -	207	635	343	158	73	32	1448
— > 8 -	—	4	127	159	175	27	492
St. Andrews Bay: Position D.	2974	1983	722	330	11	—	6020
— — C.	886	1640	1238	502	23	—	4289
— — B.	4943	1945	1088	448	15	1	8440
— — A.	337	978	971	658	103	2	3049

It is apparent that the population in St. Andrews Bay is much greater numerically than that of Aberdeen Bay; this feature is not confined to particular size-groups, but is manifest in all sizes except those above 25 cm., which are more numerous in the latter locality.

It was shown during the examination of the food that the plaice above 10 cm. in length in Aberdeen Bay feed on *Nephthys*, *Arenicola*, *Lanice* and sandeels, whereas those in St. Andrews Bay exploit several other species as well.

There are thus two distinct plaice populations, the smaller of which grows faster while feeding on fewer animals.

The results stress the importance of elucidating the relationship between the food and the fauna of the bays; in particular it is desirable to estimate the relative amounts available in each bay for the respective populations.

When the volumetric contents of the stomach are considered they suggest that the plaice in Aberdeen Bay feed more abundantly during the main growth period than those in St. Andrews Bay.

In this connexion Section (a) of the table for each bay shows, for the different trawling positions, the average quantities of food contained in the stomachs of a hundred fish of each size-group from May to September, while the following are the respective averages for each bay as a whole:—

c. c. p. 100 Fish cm.	<11	11-15	16-20	21-25	26-30
Aberdeen Bay....	6·5	41	80	98	157
St. Andrews Bay..	3·5	17	42	62	90

In the case of the plaice under 11 cm. in St. Andrews Bay the average volumes in the different trawling positions vary from 2·5 to 5. c. c. per 100 fish, giving, as shown above, an average of 3·5 c. c.: the relative figure for Aberdeen Bay is 6·5 and is thus approximately 1·8 times that of St. Andrews Bay. Similarly the volumes for the 11—15 cm. group in St. Andrews Bay vary from 8·5 to 22 c. c. per 100 fish, the average for the whole bay being 17 c. c.; the corresponding average in Aberdeen Bay is 2·4 times that figure.

The volumes for the three size-groups between 16 cm. and 30 cm. show features similar to those of the smaller fish. They are particularly high in the shallow water in Aberdeen Bay owing to the large consumption of sandeels, while the averages for that bay as a whole are respectively 1·9, 1·6, and 1·7 times those of St. Andrews Bay.

11.

The Food of Post-larval Haddock with Reference to the annual Fluctuations in the Haddock Broods.

BY

Helen S. Ogilvie, Aberdeen.

connexion with the study of the annual fluc-uations in the broods of the haddock in Scottish rs, an examination of the food of the post-larval s was undertaken with a view to determining her variations in the plankton, such as relative dance of the food organisms and their time of rance from year to year influence the survival broods of the haddock at this critical stage in life history.

e larvae were extracted from the plankton g the routine examination of the collections ets in use being the 1-metre cheese-cloth towed ntally for a quarter of an hour at surface, mid- and bottom and the 2-metre cheese-cloth d vertically.

area was selected to cover the main Scottish ck spawning grounds in the North Sea from atitude of Aberdeen northwards and west of rkney and Shetland islands. This was divided hree sub-areas which will be referred to as Cen- Northern, and Western. Central includes the ern and Central North Sea south of $59^1/_2$°N., ern, the North Sea to the north of $59^1/_2$°N., Western, the area to the west of the Orkneys Shetlands. Collections made by the Standard Si k Net, hauled vertically, were available from o the stations at which larvae were recorded as these give the most representative picture small plankton organisms on which the baby ck feed, they were used for comparison with od contents.

Material.

t-larval haddock occur in the plankton collec- normally from March to June, being most abundant in April and May. From the material available, collections were chosen to cover the extent of the three areas as far as possible in 1934 and 1935 but all the areas are not represented each month. Owing to a somewhat later spawning of the haddock in 1935 no larvae were captured in March of that year although the Central and Northern areas were sampled at least as extensively as usual, and the larvae taken in June 1935 were not examined as only larger sizes were available.

Method.

The material, taken as it was from the ordinary plankton collections, had been preserved in formalin. When a specimen had been measured the gut was removed under a binocular dissecting microscope by making a cut in the region of the oesophagus and dissecting out the alimentary tract entire. In the case of the smallest fish no sharp differentiation could be made between stomach and intestines and for the sake of uniformity none was made in the larger sizes as the food contents of the intestine could as a rule be quite easily identified. The gut contents were then spread on one or more slides and examined under an 8 mm. object-glass, higher magnification being used when necessary. The condition of the food was such that it was found possible to identify practically the whole of the contents and counts were made of the organisms. In some of the very small fish, the food or part of it consisted of fine granular matter, the nature and origin of which could not be determined but the amount of this was so small that it has no significant effect on the results.

Food. — Relative Importance of the Food Organisms.

Tables I and II[1]) show the numbers of the most important organisms taken by the haddock at successive sizes from 3·5 mm. upwards in 1934 and 1935 respectively. The absolute predominance of copepod nauplii is at once evident in both cases. Copepodids and adult copepods are next in importance, their numbers rising with increase in the size of the fish, and copepod ova are also well represented especially in the smaller sizes. Copepods indeed, in all stages from egg to adult formed almost 90 % of the total food contents. Carrying the analysis further we find that nearly 70 % of the diet is made up of nauplius stages alone while copepodids and adults account for no more than about 12 % and copepod ova for 7 % of the whole.

With the exception of one or two records of *Podon* and *Evadne*, the only other crustacean food consisted of early stages and ova of euphausids but they are of small importance in the food as they formed only about 1 % of the stomach contents.

The remainder of the food is made up chiefly of larval molluscs and organisms of the microplankton and falls slightly short of 10 % of the total.

Food and its Relation to Size.

A complete list of the organisms found in the stomachs of the post-larval haddock during the period of this investigation is given in Table III. The importance of copepods — both adults and developmental stages — in the diet of the haddock during the early stages of its life history has already been stressed. The copepod species taken are, as is to be expected, those which occur most commonly in the plankton of our area. *Calanus* which, owing to its abundance in the plankton, heads the list, is of importance in the food chiefly in its nauplius stages. Early nauplius stages were eaten by even the smallest fish. The stomachs of fish under 4 mm. in size usually contained very little but already at 4 mm. an average content of almost three nauplii per fish was recorded. Ova of *Calanus* were also taken by the youngest fish. The highest average numbers of nauplii per stomach occur in fish of 12—15 mm.; above this size they are partially and gradually replaced by copepodid stages and adults of the smaller copepod species, although instances of heavy feeding on nauplii have been noted among the larger fish. Small copepodids are eaten by fish of 6—7 mm. copepodid stage V and adults by the largest sizes examined only, which indicates the probability that they would form an important factor in the food of the larger pelagic stages before the bottom feeding habit is acquired. A very large proportion of the nauplii referred to as "calanoid" in the tables of distribution were those of *Calanus* but those of *Pseudocalanus*, *Metridia*, *Temora* and *Acartia* were included for the sake of simplicity.

[1]) See pages 62—66.

Table III.

Copepods	Cladocera
Calanus finmarchicus	*Podon intermedius*
Pseudocalanus minutus	*Evadne nordmanni*
Temora longicornis	
Centropages typicus	Molluscs
Acartia clausi	*Limacina retroversa*
Paracalanus parvus	Lamellibranch juvs.
Microcalanus pusillus	Gastropod —
Stephos lamellatus	
Oithona helgolandica	Tintinnids
— *spinirostris*	*Stenosemella nucula* Jörg.
Harpacticoid	— *ventricosa* Jörg.
	Acanthostemella norvegica (Dad.)
Copepodids	*Favella denticulata* (Ehrbg.) Jörg.
Calanus finmarchicus	
Pseudocalanus minutus	Diatoms
Metridia lucens	*Coscinodiscus centralis*
Temora longicornis	— *subbulliens*
Acartia clausi	— *radiatus*
Microcalanus pusillus	— *marginatus*
Oithona helgolandica	— spp.
— *spinirostris*	*Chaetoceros borealis*
	— *decipiens*
Nauplii	— *constrictus*
Calanus	— *contortus*
Pseudocalanus	— *debilis*
Metridia	— spp.
Temora	*Bacteriastrum* sp.
Acartia	*Thalassiosira decipiens*
Oithona	— sp.
Longipedia	*Rhizosolenia styliformis*
Microsetella	*Cerataulina bergonii*
	Hyalodiscus stelliger
Ova	*Paralia sulcata*
Calanus	*Nitzschia seriata*
Pseudocalanus	*Thalassiothrix nitzschioides*
Centropages	*Pinnularia* sp.
Oithona ovisacs	*Fragilaria* sp.
	Dinoflagellates
Euphausids	*Peridinium depressum*
Furciliae	*Dinophysis* sp.
Calyptopes	*Glenodinium* sp.
Nauplii	
Ova	Round cells (plant?)

Next in importance to *Calanus* is the copepod *Oithona*. Both *O. helgolandica* and *O. spinirostris* occur, the former being considerably the more common. The two species were not separated in the examination of the food. It forms a poor second to *Calanus*, however, its nauplii being outnumbered by the "calanoids" in the proportion of 6:1, but owing doubtless to its small size as well as to its frequency in the plankton it takes first place among the adults, having been found in the mature state in fish of 6 and 7 mm. while copepodids were taken at 5 mm. There is no evidence in these records, however, that its small nauplii are taken in preference to the calanoids on account of size by even the smallest fish.

this may depend on availability. It is followed *udocalanus* which is common in all stages gg to adult, mature females being taken freely of 12 mm. and over and occasionally by those ller size. *Temora*, *Acartia* and *Metridia*, which ilar in size, occur quite frequently but with gularity and in much smaller numbers, while naining copepod species on the list furnish casional records.

rest of the crustacean food is of minor im-e. Euphausids are represented chiefly by s and calyptopis stages most of which were by reference to the plankton to be those of *oessa*. They were found in fish of 12 mm. and s and are probably of increasing importance food of the later pelagic stages. The small rans *Podon* and *Evadne* were observed only nally throughout.

t from the tintinnids which according to size re appropriately dealt with along with the ms of the phytoplankton, the principal non-ean food consists of molluscs. Of these *Lima-*the most important followed by larval lamelli-. Larval gastropods occurred but very occa-. Combining the numbers of *Limacina* and branchs for the two seasons of the investiga-e find that they form less than 2·5 % of the od. The *Limacina* were found mostly in the fish and were themselves very small; some must have been practically newly-hatched. plankton organisms were represented in the tintinnids, diatoms and dinoflagellates. As expected, these organisms figure only in the hs of the smallest fish and drop out of the when a size of 5·5—6 mm. is reached, as e to Tables I and II shows. When they were d in the contents of the stomachs of larger g., over 12 mm. as was occasionally the case, ere not tabulated as it was thought probable ey had escaped from the burst guts of ingested ls. Numerically the microplankton organisms ly about 7 % of the total food. This percen-ure is in itself misleading owing to the minute the organisms it represents. While the young *na* and lamellibranchs and perhaps the larger *Coscinodiscus* spp. among the diatoms approach ne order of size as the smallest units among epods, viz., the ova, the remainder, tintinnids, s and dinoflagellates are very much smaller. king example is afforded by the tinninnid *mella nucula* which numerically accounted for % of the food organisms in 1934. It would over 40 of its small vase-shaped tests to *Calanus* egg in volume and its frequency in 4 material is the chief reason that the percent-non-crustacean food in 1934 is nearly double 1935. Far from being weighted in their favour, re, the percentages of crustacean food would een relatively still higher if calculated on a tric basis.

her examination of the counts shows that of the 422 micro-organisms enumerated about 65 % consists of the *Stenosemella nucula* referred to above which with its tiny tests covered with minute particles of inorganic matter seems a very unpromising article of diet. It is impossible to say even from a microscopic examination whether the tests, when ingested, contained the tintinnid organism or whether they were empty and discarded. Nevertheless 273 of these were counted in the stomach contents as against 19 belonging to the other species of tintinnids observed. The list of species of diatoms identified looks formidable but they are in themselves so small and so few in number that their presence in the food contents is of little importance.

If it be granted that practically all the microplankton consumed as food is taken by the smallest sizes and that it ceases to have significance in fish of over 5 mm., we find that only 26 fish out of a total of 167 measuring from 3·5 to 5 mm. or 15 % fed on microplankton only, 30 % on nauplii only and 40 % on a mixed diet, while the stomachs of the remaining 15 % contained no food. Further work on these early stages might modify these results somewhat, but so far as the present investigation goes, there is no evidence that microplankton organisms form an essential part of the food of even the earliest feeding stages.

Yolk-Sac Stages and Feeding.

The yolk-sac in varying degrees of absorption was observed in 19 specimens, 9 of which measured 3·5 mm., 9, 4 mm., and 1, 4·5 mm. The stomachs of 9 of these irrespective of size contained no food. In those which had been feeding, the food was similar in character and amount to that taken by fish of corresponding size which showed no yolk-sac. That the presence of yolk-sac is no deterrant to the taking of food is shown by the following examples: the stomach of one fish 3·5 mm. in size contained 3 calanoid nauplii (Stage II or III), 2 nauplii of *Oithona* and 1 ovum of *Calanus*, while another at 4 mm. contained 1 calanoid nauplius (Stage IV), 4 nauplii of *Oithona*, 3 *Acanthostomella* and a fragment of a chain of *Chaetoceros decipiens*. It is evident from examples such as these that the haddock in its earliest stages is capable as soon as it feeds at all of ingesting the nauplii which form the mainstay of its food during its subsequent post-larval existence.

Amount of Food in the Stomachs.

Very few of the fish examined had no food in their stomachs and the majority had been feeding heavily. Only 32 of the 316 stomachs examined were empty and more than half this number is accounted for by the fact that in the 1935 material special attention was paid to the smallest sizes, a larger proportion of which contained no food. Actually 22 of the 32 empty stomachs were taken from fish measuring 3·5 and 4 mm. The remainder is so small a fraction of the whole that it precludes the possibility of explaining absence of food in the stomachs by lack of suitable food in the environment.

The numbers of copepod nauplii which form a very high percentage of the food, may be used to give a rough estimate of the degree of feeding. Table IV shows the average number of nauplii found in the stomachs at successive sizes. The decrease in numbers in the largest specimens is to be explained by the partial change in diet at this stage to copepodids and adult copepods.

Table IV.

Size of Fish mm.	3·5	4	4·5	5	6	7	8	9	10	11	12	13	14	15
Av. No. of Nauplii p. Fish.	0·6	2·8	6	10	14	18	21	20	19	17	56	50	33	31

The following selected examples of intensive feeding will convey some idea of the amazing capacity of the baby haddock. The stomach contents of individual specimens were as follows: —

5 mm.		19 mm.	
22	Calanoid nauplii	50	*Oithona* (adults)
5	Nauplii of *Oithona*	2	*Acartia* (adults)
5	Copepod ova	2	*Pseudocalanus* (adults)
	Bacteriastrum (part of a chain)	1	*Paracalanus* (adults)
		21	Copepodids of *Calanus*
		24	— of *Acartia*
8 mm.		3	— of *Pseudocalanus*
1	Copepodid of *Microcalanus*	2	— of *Metridia*
6	— of *Oithona*	4	— of *Oithona*
3	Calanoid nauplii	140	Calanoid Nauplii
2	Nauplii of *Oithona*	1	Euphausid calyptopis
2	— of *Longipedia*	7	— nauplii
2	Ova of *Calanus*	2	*Limacina*
6	*Limacina*		
3	*Coscinodiscus*		

Parasites.

Only two trematodes were observed during the course of the work in fish of 8 mm. and 13 mm. respectively. This is in marked contrast to the condition prevailing in the post-larval herring in which the writer found a heavy infection both of trematodes and cestodes even in the very young stages (Ogilvie, 1927).

The Food and its Relation to the Plankton.

As copepod nauplii form such a large proportion of the food their presence in adequate numbers in the plankton must be of supreme importance to the welfare of the post-larval haddock and also one of the controlling factors in brood survival. The plankton collections on which the following data are based, are from vertical hauls made with the Standard F. S. net at the same stations and times at which the larvae examined were captured. The average volumes of those collections for the different months and areas are given in Table V, column 2. The fluctuations in volume of the plankton were very co siderable, values varying from 1 c. c. to 110 c. settled volume having been recorded during t period of the investigations but these depend large especially in the spring months, on the quantity phytoplankton and particularly of diatoms presen As phytoplankton organisms have been shown be of minor importance in the food of the larva counts were made of the nauplii in the collection Each collection was made up to a standard quantit by the addition of liquid. It was then stirred we and a fixed amount withdrawn in a pipette and ru into a petri dish. Using the same magnificatio throughout, the nauplii in a certain number of field of a binocular microscope were counted and it from these figures that the "average relative counts have been compiled. The counts are thus not absolut but are strictly comparable *inter se* and represen the relative abundance of nauplii at the differen stations. The average values of these counts are give in Table V, col. 3.

Table V.

		Number of Stations	Average Volumes of Plankton Collections	Average Relative Counts of Nauplii
1934				
March	Central	2	5·5 c.c.	49
	Northern	3	25·0	72
	Western	2	28·0	42
April	Central	4	11·0	144
	Western	10	18·0	109
May	Central	5	29·0	99
	Northern	12	22·0	106
1935				
March	Central	7	7·0	19
	Northern	15	5·5	43
April	Central	8	26·0	214
	Northern	9	22·0	168
May	Central	8	15·0	178
	Western	9	33·0	250

In the early part of the year an increased influx of water from the Atlantic takes place normally round the N. of Shetland into the North Sea. This water pushes before it and carries with it plankton which helps to replenish the stock in the North Sea and also produces conditions favourable to the growth and rapid multiplication of species already present. These conditions are reflected in the volumes of the plankton samples as shown in Table V, col. 2. The low values which occur in March may be taken to represent winter conditions before the spring increase has taken effect. In March 1934 the scarcity of plankton is confined to the central area and the effects of the increase are already apparent in the high volumes of plankton recorded in the north and west. In March 1935 the scarcity extends over the north as well indicating that the Atlantic effect was later in that area.

results of the examination of the macroplankton s taken during this period, which show that nkton made its appearance later in that year, n these observations. No haddock larvae were in the collections in March 1935 though samp- as carried out as usual and over a similar This was probably due to a later spawning. e now consider the main source of food of the viz., the nauplii, we find that the lowest e counts also occur in March of both years r similar reasons. These values, however, do ry directly with the volumes of plankton and the general conditions for March are such as een described, they probably depend to some on the amount of breeding of indigenous d species of which *Pseudocalanus* is the most ant. The question what constitutes a suffi- iet for the larvae depends on so many inter- factors that it cannot be settled from the data le here, but a comparison of the numbers plii found in the stomachs with those in the on may be helpful. In Table VI alongside the e relative counts of nauplii in the plankton,

Table VI.

		Average Counts of Nauplii in the Plankton	Average Numbers of Nauplii in Stomach Content
April	Central.....	144	3
	Western	109	12
May	Central.....	99	24
	Northern ...	106	24
April	Central.....	214	29
	Northern ...	168	7
May	Central.....	178	16
	Western	250	14

erage numbers of nauplii in the stomachs have rranged. In this case the figures for April and ly have been used as during that period normal ions with regard to plankton, and hatching ding of larvae may be presumed to be estab- When these figures are correlated, we find that he lowest count of nauplii in the plankton — the Central area in May 1934 — the larvae ble to obtain a stomach content of 24 nauplii . As this value is the highest but one recorded, erence is that in every case the nauplii in the were more than sufficient for the requirements fish. This applies to the larvae in general tive of size and to normal feeding conditions. beginning of the hatching season, however, riod covered by our March records, conditions otherwise. Nauplii are very much scarcer — y speaking the counts are less than half the lowest figures obtained in April and May. Larvae if present are newly-hatched and in their fragile and feeble condition probably require to be surrounded by an even greater concentration of nauplii to obtain an adequate supply of food than the older stages which are more capable of active movement in catching their prey. Regarded from the point of view of food supply alone, it would seem probable that there is a considerable mortality of newly-hatched larvae especially at the beginning of the season before normal feeding conditions have been established.

When all this has been said, however, certain points remain for which no satisfactory explanation has been found. The most striking of those is the lack of correspondence between the counts of nauplii and the stomach content of the fish. In Table VI the fluctuations in the average counts of nauplii in the plankton are only such as might have been expected but the differences in the average stomach content of nauplii are surprising, being actually about four times as great. Taking 16 nauplii as a fair average for the stomach content, feeding was conspicuously poor in April 1934, particularly in the Central area where the count of nauplii in the plankton was the highest for the season and also in April 1935 in the Northern area where again there was obviously no scarcity of nauplii. It was at first considered possible that the latter low feeding value — an average stomach content of 7 nauplii — might have been influenced by the large number of early larvae with small feeding capacity examined but a further analysis of both this and the unusually high value of 29 for the Central area in the same month, made by separating the fish into two groups below and above 5 mm. respectively showed little alteration in the relative proportions.

April 1935	Average Counts of Nauplii in Plankton	Average Stomach Content of Nauplii	
Central	214	29 in 21 fish 3·5—12 mm.	11 in 7 fish up to and including 5 mm. 38 in 14 fish over 5 mm.
North	168	7 in 95 fish 3·5—12 mm.	5·7 in 76 fish up to and including 5 mm. 14 in 19 fish over 5 mm.

Further reference to Table VI shows that the feeding values for May 1934 were well above the average though the counts of nauplii were low, while the highest count of all — 250 in May, 1935 — gave an under-average feeding value of 14. Obviously there are factors at work here which our present data are insufficient to explain, but it is at least evident that the degree of feeding as represented by the average number of nauplii found in the stomachs is not directly dependent on the number of

nauplii in the plankton and that the abundance of nauplii during the season of post-larval feeding in 1935 had no direct bearing on the successful haddock brood of that year.

With the exception of the nauplii the organisms in the plankton were not counted and so a detailed correlation of the plankton and the food is not possible.That selection in the wide sense is exercised by the larvae is abundantly proved by the uniformity of the food taken and is apparent even in the earliest feeding stages, but generally speaking little discrimination is made between the different elements of the copepod food except with regard to size. Ova and early nauplii are taken by the smallest fish and older nauplii, copepodids and adults by the larger sizes. The copepods which are commonest in the area, viz., *Calanus*, *Pseudocalanus* and *Oithona*, also preponderate in the food and fluctuations in the relative numbers of those and one or two additional species are reflected in the stomach contents. For instance *Pseudocalanus* which is probably the most generally distributed copepod in our waters was observed to be specially abundant both in the food and in the plankton in May 1935 in the Western area, *Temora* in May 1934 in the Central, *Oithona* in April 1935 in the Northern area and *Acartia* in May 1935 in the Western, while *Calanus* copepodids and nauplii were numerically conspicuous in the Central area in May 1934. Up to a point of course this is only to be expected but these and similar correspondences occur with sufficient frequency to indicate at least that the abundance of a particular species in the food is due to its predominance in the plankton rather than to its deliberate selection by the fish. While the "calanoids" were by far the most generally abundant of the nauplii in the food, there was an exception to this condition in April 1935 in the Northern area when the nauplii of *Oithona* outnumbered them by more than 2 to 1. This reversal of the usual relative proportions indicates an unusually high concentration of *Oithona* nauplii in the plankton rather than preference on the part of the fish for this particular kind of nauplii. The *Oithona* nauplii were much in excess of the "calanoid" both in larvae under 5 mm. and in the larger sizes.

In the case of the remaining constituents, the correspondence between food and plankton is less marked but this is mainly due to the smaller number of organisms dealt with. It is tempting at least in the case of the very young larvae to regard the non-crustacean elements and particularly the organisms of the microplankton as a sort of stop-gap to be made use of when there is a shortage of nauplii. For instance in March 1934 when the average counts of nauplii were the lowest recorded (except in March 1935 when there were no larvae) the numbers of microplankton organisms in the stomachs were higher than at any other time during the investigation. The actual figures are given in the following table:

March 1934.

	Central	Northern	Western
Number of Larvae..	9	10	7
Size in mm.....	4·0—4·5	3·5—5·5	4·0—5·0
Microplankton Organisms in Food..	63	42	73
Average Counts of Nauplii in Plankton	49	72	12

Admittedly too much stress must not be laid on isolated observations of this kind and a similar combination of conditions which might have served as a control did not recur during the period of the work.

While correspondence between food and plankton is the rule, a few exceptional cases may be mentioned. The adult *Oithona* found in the food were practically all males. This was particularly noticeable in the Western area in May 1935 when *Oithona* was very abundant. In the food of the fish examined for that month, 138 specimens were counted of which only 3 were females. Usually the numbers were small but the stomach of one fish 14 mm. in length contained 56 male *Oithona* and another of 19 mm. contained 50. In average plankton samples females considerably outnumber males and in the collection taken at the same station as the latter of these specimens, the proportion of females to males was found to be 12 to 1.

The case of the nauplii of *Longipedia* is somewhat similar. These, though not actually rare in the plankton, occur only sparsely. In the food of the fish examined for April 1935, 22 of these were counted, two fish of 6·5 and 8·5 mm. respectively each containing 8. In the plankton at this season, nauplii of *Balanus* which have a certain superficial resemblance to those of *Longipedia*, also occurred but no single instance of their occurrence in the food was noted either at this time or during the whole course of the investigation. Similar instances are mentioned by Lebour (1917) who found *Euterpina acutifrons* in greater numbers in the food of post-larval fish than in the plankton, and *Oncaea* in the food though not recorded in the plankton.

The tintinnid *Stenosemella nucula* referred to above which occurred in considerable numbers in the food of the smaller sizes, was so rare in the plankton samples that at first it was overlooked. In this case, however, the explanation of the discrepancy may be that owing to its minute size it passed through the meshes of the net.

Finally it may have been noticed that the numbers of dinoflagellates recorded in the food are very small. There seems to be no reason why these should not form part of the food of the young stages as diatoms and tintinnids do and their scarcity is probably due to the fact that their period of abundance in the Scottish plankton falls later in the year.

Summary.

he food of post-larval haddock taken on the cottish spawning grounds in 1934 and 1935 has een examined.

bout 70 % of the food consists of copepod nauplii nd these with adults, copepodids and ova account r almost 90 %. The remainder consists of early ages of euphausids, larval molluscs and micro-ankton organisms.

he fish had been feeding well. Empty stomachs ere remarkably few and they occurred chiefly the 3.5 mm. and 4 mm. sizes.

4. Comparison of the average numbers of nauplii in the stomachs and the counts of nauplii in the corresponding plankton samples indicates that the number of nauplii in the environment under normal conditions is more than sufficient to provide for the requirements of the fish.
5. The uniformity of the food shows that selection is made even by the very young stages.
6. The temporary predominance of a particular copepod species in the plankton may also be evident in the stomach contents.

Table I.

1934. Numbers of Organisms in successive Sizes of Post-larval Haddock.

Size in mm.	3.5	4	4.5	5	5.5	6	7	8	9	10	11	12	13	14	15	16	17	Totals	%		
ock: No. of Specimens	3	16	11	11	2	9	11	7	8	6	5	3	2	—	3	—	1	98			
Copepods																					
docalanus	—	—	—	—	—	—	—	—	1	2	—	2	—	—	9	—	3	**17**	0·76		
ora	—	—	—	—	—	—	—	—	—	—	—	2	1	—	2	—	—	**5**	0·22		
na	—	—	—	—	—	—	1	—	2	—	3	5	3	—	8	—	4	**26**	1·17		
r Copepods...	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	**2**	0·09	2·24	
Copepodids																					
nus.....	—	—	—	—	—	—	1	4	1	1	6	38	2	—	28	—	31	**112**	5·04		
docalanus	—	—	—	—	—	—	—	1	5	5	8	2	—	—	—	—	10	**31**	1·39		
ora	—	—	—	—	—	—	—	—	1	1	—	6	—	—	11	—	—	**19**	0·85		
tia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	**2**	0·09		
na	—	—	3	—	1	—	1	11	3	1	5	3	2	—	2	—	—	**32**	1·44		86·49 %
r Copepodids .	—	—	—	—	1	—	1	1	1	7	—	—	2	—	2	—	—	**15**	0·67	9·48	
Nauplii																					
noid	—	16	33	67	20	75	141	122	127	166	82	343	57	—	139	—	44	**1432**	64·39		
na	1	2	9	9	3	5	12	6	5	3	1	2	1	—	—	—	—	**59**	2·65		
r Nauplii	—	1	1	—	—	8	—	2	4	—	—	2	4	—	—	—	—	**22**	0·99	68·03	
Ova																					
nus.....	1	7	8	15	2	11	25	5	3	3	13	8	3	—	1	—	—	**105**	4·72		
docalanus	—	—	—	1	—	—	—	—	—	20	—	4	—	—	5	—	—	**30**	1·35		
entified	—	1	2	3	1	—	—	1	3	2	—	—	—	—	—	—	2	**15**	0·67	6·74	
Euphausids																					
nes.....	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	3	**4**	0·18	0·18	
cina juvs.	—	—	—	4	1	—	—	6	—	—	—	2	9	—	—	—	—	**22**	0·99		
ellibranch juvs.	—	—	—	1	1	—	—	—	2	—	—	—	—	—	—	—	1	**5**	0·18	1·17	
oscmella	12	85	55	32	—	—	—	—	—	1	—	—	—	—	—	—	—	**185**	8·32	8·32	
Coscodiscus spp..	—	3	—	4	1	1	—	3	1	—	—	—	—	—	—	—	—	**13**	0·58		
Rhizosolenia spp....	—	21	6	1	2	—	—	—	—	—	—	—	—	—	—	—	—	**30**	1·35		
Chaetoceros spp....	—	1	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	**3**	0·14		
r Diatoms ...	—	21	5	2	—	1	—	1	—	1	—	—	—	—	—	—	—	**31**	1·39		
Ceratium depress.	—	—	—	—	1	—	—	—	—	—	2	—	2	—	—	—	—	**5**	0·22		
r Dinoflagellat.	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**3**	0·14	3·82	
																		2225		99·98	

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Table IA.

1934. The Food of Post-larval Haddock in the Months and Areas examined.

	March				April			May			June			
Number of Fish examined	9	10	7	26	12	9	21	25	15	40	3	8	11	98
Size in mm.	Central 4.0—4.5	North 3.5—5.3	West 4.0—5.0	Totals	Central 4.0—9.0	West 3.0—7.0	Totals	Central 4.0—17.0	North 5.0—12.0	Totals	Central 5.0—9.0	West 6.0—15.0	Totals	Totals
Copepods														
Pseudocalanus	—	—	—	—	—	—	—	7	3	**10**	—	7	**7**	17
Temora	—	—	—	—	—	—	—	5	—	**5**	—	—	—	5
Acartia	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oithona	—	—	—	—	—	—	—	17	6	**23**	—	3	**3**	26
Other Copepods	—	—	—	—	—	—	—	1	1	**2**	—	—	—	2
Copepodids														
Calanus	—	—	—	—	3	—	**3**	97	8	**105**	—	4	**4**	112
Pseudocalanus	—	—	—	—	—	—	—	11	10	**21**	—	10	**10**	31
Temora	—	—	—	—	—	—	—	18	1	**19**	—	—	—	19
Acartia	—	—	—	—	—	—	—	2	—	**2**	—	—	—	2
Oithona	—	1	3	**4**	13	—	**13**	10	5	**15**	—	—	—	32
Other Copepodids	—	1	—	**1**	2	—	**2**	9	—	**9**	—	3	**3**	15
Nauplii														
Calanoid	3	30	7	**40**	15	97	**112**	602	311	**913**	49	318	**367**	1432
Oithona	—	11	6	**17**	13	4	**17**	1	23	**24**	—	1	**1**	59
Other Nauplii	1	—	—	**1**	12	3	**15**	6	—	**6**	—	—	—	22
Ova														
Calanus	2	10	5	**17**	6	21	**27**	24	35	**59**	—	2	**2**	105
Pseudocalanus	—	—	1	**1**	—	—	—	24	—	**24**	—	5	**5**	30
Undetermined	—	2	2	**4**	3	2	**5**	6	—	**6**	—	—	—	15
Euphausids														
Juvenes	—	—	—	—	—	—	—	4	—	**4**	—	—	—	4
Ova	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Limacina	—	2	—	**2**	9	—	**9**	11	—	**11**	—	—	—	22
Lamellibranch juvs.	—	1	—	**1**	—	—	—	1	2	**3**	1	—	**1**	5
Stenosemella	9	33	68	**110**	39	35	**74**	1	—	**1**	—	—	—	185
Other Tintinnids	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coscinodiscus spp.	1	1	3	**5**	8	—	**8**	—	—	—	—	—	—	13
Chaetoceros spp.	27	2	1	**30**	—	—	—	—	—	—	—	—	—	30
Rhizosolenia styliformis	2	—	—	**2**	—	—	—	1	—	**1**	—	—	—	3
Other Diatoms	23	3	1	**27**	2	1	**3**	1	—	**1**	—	—	—	31
Peridinium depressum	—	1	—	**1**	—	—	—	4	—	**4**	—	—	—	5
Other Dinoflagellates	1	2	—	**3**	—	—	—	—	—	—	—	—	—	3

Table II.

1935. Number of Organisms in successive Sizes of Post-larval Haddock.

in mm.	3.5	4	4.5	5	5.5	6	7	8	9	10	11	12	13	14	15	16	18	19	23	31	Total			
of Specimens	18	39	38	31	9	10	12	10	15	8	6	6	2	4	3	2	2	1	1	1	218			
cds																								
us	—	—	—	—	—	—	—	—	3	—	—	2	1	12	6	8	3	2	21	—	**58**	1·45		
.....	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	**2**	0·05		
.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	**2**	0·05		
.....	—	—	—	—	—	1	—	4	3	1	1	8	3	57	2	9	3	50	—	—	**142**	3·56		
ods . . .	—	—	—	—	—	—	—	—	—	—	—	1	1	3	1	—	3	1	—	1	**11**	0·27	5·38	
didds																								
.....	—	—	—	1	—	—	6	2	8	1	5	17	—	2	8	2	12	21	—	8	**93**	2·33		
us	—	—	—	—	—	—	1	7	6	2	31	3	7	4	6	4	3	3	1	—	**78**	1·96		
.....	—	—	1	—	2	—	—	1	3	—	8	—	—	20	1	—	—	—	—	—	**36**	0·90		
.....	—	—	—	—	—	—	—	—	3	—	1	—	—	1	1	16	6	24	—	1	**53**	1·33		
.....	—	—	—	5	5	8	17	11	28	5	4	1	—	—	—	—	4	—	—	—	**88**	2·21		
odids. .	—	—	—	—	1	—	1	—	—	—	4	—	—	—	—	—	—	2	—	—	**8**	0·20	8·93	
lii																								
.....	9	65	160	233	151	94	157	218	264	101	101	157	139	129	25	74	5	140	2	—	**2224**	55·79		
.....	2	65	100	152	45	25	74	11	43	—	1	1	1	4	2	—	—	—	—	—	**526**	13·20		
ii	—	1	—	1	5	8	—	—	8	—	—	—	—	—	—	—	—	—	—	—	**23**	0·58	69·57	
.....	7	18	30	24	3	3	4	25	47	8	146	2	5	8	—	—	—	—	—	1	**331**	8·30		
us	—	—	—	—	—	—	—	—	30	—	5	—	48	130	54	200	8	—	240	—	***715**			
.....	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	**2**	0·05	8·35	
sids																								
.....	—	—	—	—	—	—	1	—	2	—	7	1	—	5	—	3	1	8	—	—	**28**	0·70		
.....	—	—	—	—	—	—	—	2	1	—	—	—	—	1	—	—	—	—	—	—	**4**	0·10	0·80	
ws.	—	6	16	18	10	11	17	9	14	11	1	—	—	—	—	2	—	—	—	—	**115**	2·88		
h juvs. .	—	1	2	—	5	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	**10**	0·25	3·13	
.....	3	5	47	18	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**88**	2·21		
nids....	4	8	6	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**19**	0·48	2·69	
spp....	2	17	9	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**34**	0·85		
pp.....	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**3**	0·08		
ns	—	4	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**5**	0·13		
lepressum	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	**3**	0·08	1·14	
																					3986		99·99	

92.23 %

va of *Pseudocalanus* omitted from Total because probably ingested as ovisecs.

Table II A.

1935. Food of Post-larval Haddock in the Months and Areas examined.

	April					May				
Number of Fish examined	7	14	76	19	116	13	38	51	102	218
Size in mm.	Central 3.5—5	Central 5.5—12	North 3.5—5	North 5.5—12	Totals	Central 3.5—14.5	West 3.5—5	West 5.5—31	Totals	Totals
Copepods										
Pseudocalanus	—	1	—	1	**2**	7	—	49	**56**	58
Temora	—	—	—	—	—	1	—	1	**2**	2
Acartia	—	—	—	—	—	—	—	2	**2**	2
Oithona	—	1	—	3	**4**	4	—	134	**138**	142
Other Copepods	—	—	—	—	—	2	—	9	**11**	11
Copepodids										
Calanus	1	16	—	—	**17**	5	—	71	**76**	93
Pseudocalanus	—	—	—	5	**5**	12	—	61	**73**	78
Temora	—	10	—	—	**10**	23	—	3	**26**	36
Acartia	—	—	—	—	—	—	—	53	**53**	53
Oithona	1	3	4	59	**67**	—	—	21	**21**	88
Other Copepodids	—	6	—	—	**6**	—	—	2	**2**	8
Nauplii										
Calanoid	75	507	129	86	**797**	205	235	987	**1427**	2224
Oithona	3	25	304	162	**494**	9	10	13	**32**	526
Other Nauplii	—	2	—	21	**23**	—	—	—	—	23
Ova										
Calanus	11	12	21	7	**51**	16	34	230	**280**	331
Pseudocalanus	—	—	—	30	**30**	102	—	583	**685**	715
Undetermined	—	—	—	—	—	1	1	—	**2**	2
Euphausids										
Juvenes	—	9	—	—	**9**	—	—	19	**19**	28
Ova	—	1	—	1	**2**	—	—	2	**2**	4
Limacina	—	—	39	49	**88**	—	1	26	**27**	115
Lamellibranch juvs.	—	6	3	—	**9**	—	—	1	**1**	10
Stenosemella	—	—	67	15	**82**	3	3	—	**6**	88
Other Tintinnids	1	—	7	—	**8**	7	4	—	**11**	19
Coscinodiscus spp.	—	—	33	1	**34**	—	—	—	—	34
Chaetoceros spp.	—	—	1	—	**1**	—	2	—	**2**	3
Other Diatoms	—	—	4	1	**5**	—	—	—	—	5
Peridinium depressum	—	—	2	1	**3**	—	—	—	—	3
Other Dinoflagellates	—	—	—	—	—	—	—	—	—	—

12.

On the Norwegian Research Work concerning *Pandalus borealis*.

BY

J. T. Ruud.

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uring the years 1933 to 1936 we have conducted, from the Biological Laboratory, investigations the deep-sea prawn fishery. The results of these shown in a paper entitled "Deep-Sea Prawn ries and their Problems", which Professor T and I have written, and which has been shed as *Hvalrådets Skrifter* Nr. 17.

this paper we have reviewed the development e prawn fisheries from their commencement in up to, and including, the year 1935, and re- d on our own investigations in recent years. r studies were based mainly on trawling experi- s for the purpose of investigating three different ems connected with present day prawn fishing: Trawlings were first undertaken on the old ng grounds to enable us to obtain a basis for g the effect of 35 years of fishing on the size e prawn stock, and also that we might study una on the grounds as it is revealed in the catches.

Furthermore, with the help of experienced trawlers, we carried out a survey of the extent known prawn-grounds, and investigated the ilities of expanding the industry in waters to not fished, namely those of the Norwegian nel to the north of the Reef off Egersund.

As a natural consequence of the experience thus i, we continued with a series of trawlings with f different sizes of mesh, to enable us to deter- whether prawn trawling is or is not carried a rational manner.

investigations which Hjort undertook in eration with Dr. Bigelow in the Gulf of Maine autumn of 1936 yielded further material of t for our problems.

following is a brief summary of our results: Our trawling experiments on the old trawling ds clearly showed that the yield of the fishery had declined considerably. For instance in the Oslofjord inside Drøbak, the average yield in 1905 to 1906, a few years after the commencement of the fishery, was some 44 kg. per fishing day. In the years 1934 to 1936 the average yield for the trawlers working on a commercial basis was from 8 to 13 kg. per fishing day. And this decrease has taken place in spite of improvement in gear and the increased knowledge of the grounds gained over a period of 30 years.

In the case also of the prawning grounds on the Reef, which were first worked as recently as 1929 and 1930, the latest reports show decreasing catches. This trend in the yield of the fishery is, however, a natural consequence of the fact that an old and accumulated stock is fished when a fishery first commences, whereas, after the lapse of a few years, the yield of the fishery becomes dependent on the annual renewal of the stock.

2. Our survey of the existing and possible new trawling grounds showed that, in southern Norway, there are no possibilities for an expansion of the fishery by extension of the grounds. In the fjords, and in territorial waters, we may assume that practically all possible grounds worth working are known, while in the open waters of the Skagerak, the trawlings on the Reef produced decreasing catches as we moved northwards from the well-known ground off Egersund. From our trawlings in the Norwegian Channel towards Stadt and Tampen it was evident that a necessary condition for the presence of prawns is a muddy bottom, rich in organic detritus. This was also the experience gained during the trawlings in the Gulf of Maine. The quantity of prawns declines gradually with the disappearance of detritus from the material of the sea bed.

3. Before turning to the results of our trawlings with gear of different sizes of mesh I must mention

that, according to the Norwegian regulations governing the fishing of prawns, the meshes of the prawn-trawl must not exceed 36 knots per Norwegian ell. (Corresponding to a distance between the knots of 1·74 cm. in the dry net.)

Smaller meshes are allowed, and in many cases meshes as small as 44 knots per Norw. ell are in use. The reason for this provision with regard to a maximum mesh is, that the prawn-trawl must conform to a size which entitles it to exemption from the general prohibition against trawl fishing in Norwegian territorial waters.

In considering the question of the effect of the gear on the size of the stock, I must further draw attention to certain facts in the biology of the deep-sea prawn.

When Miss BERKELEY (of British Columbia) took up the study of the biology of different species of *Pandalus* she made the surprising discovery that *Pandalus borealis* and a number of other *Pandalus* species were protandric hermaphrodites. In other words, all individuals first mature as males, and thereafter as females, as which they remain for the rest of their lives.

As long as we believed *Pandalus borealis* to have separate sexes we did not regard the destruction of small prawns in fine meshed gear as a matter of very great importance, since all these small individuals were, without exception, males, and the males did not grow as large as the females. But, knowing, as we do now, that these males will change in a few months into females, their destruction becomes of serious consequence to the renewal of the stock of large prawns, and it is the large prawns which obtain the best price, which form the bulk of the exports, and which make the fishery a paying industry.

In our fishing experiments with gear of different sizes of mesh, we used three equally large trawls, one with a mesh of 32 knots, one with 36 knots and one with 40 knots per Norw. ell. With these trawls we made alternate hauls at different seasons, and our results may be summarized as follows:

Gear with a 32 mesh naturally takes the smallest catches of small prawns, but at all seasons the catch of large prawns is also considerably less in this gear than in the gear with smaller meshes. Gear with 32 knots to the Norw. ell, therefore, cannot be used for prawn trawling without a marked loss in yield and in the profit of the fishermen. Gear with a 36-mesh net did not make a smaller catch of large prawns than the gear with a 40-mesh net, but the catch of small prawns was considerably less. Even in the 36-mesh trawl, however, a considerable number of small prawns are destroyed, especially in the summer, but at this season of the year a certain destruction of small prawns cannot be avoided. At this time the 32-mesh trawl also takes the small prawns in numbers up to 30 per cent. of the total catch.

As a result of these experiments we drew the conclusion that the mesh with 36 knots to the ell, was best suited for prawn trawling, as it secured a good catch and afforded at least a certain degree of protection to the small prawns. We therefore recommended that this size of mesh should be laid down as a minimum, instead of a maximum size as is the case in the present regulations.

We know that most of the fishermen greatly favour this measure for the preservation of the prawn stock, but in certain localities in east Norway they have felt the need of further measures for the protection of the stock and the industry. They have discussed certain steps which might be taken, e. g., a close season, or a prohibition of canning and export in the summer.

The summer, however, is the season with the best weather conditions for the Reef fishery, and in the fishery on the Reef, Swedish and Danish fishermen also participate. A prohibition of canning and/or of export during the warm season would undoubtedly have the effect of reducing the intensity of the fishing in the summer, but these measures, as well as the question of a close season must be carefully considered in the different districts and in the different countries interested in this industry. In this fishery, as in so many others, international co-operation is a *sine qua non* if the industry is to continue to be lucrative also in the future.

13.

ber die Herstellung von Planktonkarten des Nordatlantischen Ozeans.

VON

E. Hentschel, Hamburg.

Planktonarbeiten der Internationalen Meeres-
orschung sind im ersten Jahrzehnt nach deren
ndung beherrscht gewesen durch das Bestreben,
n der Planktonverteilung im nordatlantischen
zu entwerfen. Der dafür gewählte Weg war
der. Die Sachverständigen der einzelnen Nati-
beschafften Planktonmaterial von Termin-
n auf vereinbarten Fahrtstrecken. Dies wurde
bestimmt und auch in bezug auf die Häufigkeit
nzelnen Arten abgeschätzt. Auf Grund der so
henden Planktonlisten wurden die verschie-
Organismengruppen zusammenfassend bear-
und die Ergebnisse dieser Bearbeitung in den
ins Planctoniques niedergelegt. Diese enthalten
liche Karten.

Zweck des Unternehmens lag augenscheinlich
eine allgemeine biologische Orientierung über
eeresgebiete, in denen die Arbeiten der Inter-
alen Meeresforschung stattfinden, zu ermög-
. Das Bedürfnis nach einer solchen ist natur-
s heute nicht weniger als damals vorhanden,
chon ihre unmittelbare Beziehung auf Fra-
er Fischerei heute wie damals nicht immer
Augen springt. Man wird eine solche Beziehung
mmer zunächst im Stoffwechselzusammenhang
, d. h. hauptsächlich darin, inwiefern Plankton
ahrung für Fische, insbesondere auch Jung-
in Betracht kommt. Wo eine solche Beziehung
t, muss ja die Verteilung der Fische in
menhang mit der des Planktons stehen. Dar-
hinaus hat sich die Planktonverteilung sozu-
als wegweisend erwiesen für die Verteilung und
ng der Wassermassen, die wiederum für das
ben von Bedeutung sind. Neuere englische
uchungen haben noch einen ganz anderen
menhang aufgedeckt, nämlich die Erscheinung,
ppige Bestände von Phytoplankton auf Fisch-
de ausschliessend wirken. Es scheint mir in Anschluss an diese Erfahrungen die Annahme nahe zu liegen, dass überhaupt für die Verteilung der Fische, insbesondere auch für ihre Orientierung bei Wanderungen das Plankton, auch wenn es nicht als Nahrung in Frage kommt, eine grössere Bedeutung haben könnte, als wir heute erkennen. Man wird das erst beurteilen können, wenn man die Planktonverteilung wirklich mit einiger Sicherheit kennt.

Jene alten Planktonkarten sind für manche Zwecke noch heute von grossem Wert, doch bezweifle ich, ob das der Fall sein wird inbezug auf die erwähnten fischereibiologischen Probleme. Sie sind wohl z. T. für die Behandlung der "Leitformenfrage" brauchbar, die wenigstens indirekt die Deutung der Verteilung von Fischbeständen unterstützt. Um zur Lösung der anderen, unmittelbarer wichtigen Fragen beitragen zu können, wird man dagegen wesentlich anders geartete Karten nötig haben. Das geographische Verhalten der einzelnen Arten erscheint für sie weniger bedeutungsvoll.

Unsere heutigen Vorstellungen vom Leben des Planktons sind durchdrungen von dem Produktionsgedanken. Man wird demgemäss auch bei der geographischen Betrachtung nach Darstellungen fragen, die diesem Gedanken gerecht werden, nach Karten, die irgendwie die Unterschiede in der Produktion der Meeresgebiete zum Ausdruck bringen. Das bedeutet aber offensichtlich, dass sie im Unterschiede von jenen alten Karten immer mehr das Plankton als Ganzes im Auge haben müssten, nicht seine einzelnen Arten, und dass sie die quantitative Bestimmung höher bewerten müssten als die qualitative. Man wird vielleicht am leichtesten verstehen, wie ich mir solche Karten vorstelle, wenn ich einerseits erinnere an die Grundkarten der Pflanzengeographie des Festlandes, andererseits an die ozeanographischen Karten des Salzgehalts und der Temperatur.

Ich habe mich auf Grund solcher Überlegungen

seit einer Reihe von Jahren bemüht, die Unterlagen derartiger Planktonkarten für eine bestimmte Region der nordischen Meere zu beschaffen und schliesslich solche Karten zu entwerfen. Mein Untersuchungsgebiet waren und sind die isländischen Gewässer in einem weiten Sinne des Wortes. Ähnliche Untersuchungen wurden auch für die Ostsee, für die nordwestafrikanischen Gewässer, für die subtropischen Breiten des nordatlantischen Ozeans und für antarktische Walfanggebiete teils ausgeführt, teils in Angriff genommen.

Die Beschaffung eines ausreichenden Materials für solche Karten ist naturgemäss mit grossen Schwierigkeiten verbunden. Die Absicht der gegenwärtigen Darlegung ist die, einen neuen Weg zu versuchen, um diese Schwierigkeiten zu überwinden. Was wir an Karten über die physikalischen Eigenschaften des Meerwassers besitzen, wie solche der Temperatur, des Salzgehalts, der Strömungen oder wie auch die Karten des Bodenreliefs der Meere, beruht bekanntlich auf internationaler Arbeit, nicht eigentlich auf Zusammenarbeit, aber auf gleichsinniger Arbeit, auf einer allmählichen Anhäufung von Daten, die gleichartig und daher miteinander verknüpfbar sind. Ich habe mir die Frage vorgelegt, wie weit etwas ähnliches im Bereich der Planktonforschung möglich sein möchte, und welche Mittel man anwenden könnte, es zu erreichen.

Bei den oben erwähnten Untersuchungen von mir selbst und meinen Mitarbeitern wurde nach mancherlei Überlegungen und Versuchen durchweg ein einheitliches Verfahren angewandt. Es wird vom fahrenden oder ruhenden Schiff aus von der Meeresoberfläche Wasser geschöpft und ein Quantum davon abgemessen (beispielsweise 5 Liter), das gross genug erscheint, um ein befriedigendes Ergebnis der Planktonzählung zu gewährleisten und klein genug, so dass möglichst eine Totalzählung des darin enthaltenen Planktons ausgeführt werden kann. Dies Wasser wird durch ein kleines Sieb gegossen, dessen Boden aus einer Gaze mit 40 μ weiten Maschen besteht. Das so gewonnene Plankton wird mit besonderer Sorgfalt in ein Fläschchen übertragen und konserviert. Solche Proben werden je nach den Umständen in Abständen von 5—10 und mehr Seemeilen beschafft. Die Proben werden daheim im Laboratorium nach bestimmten Grundsätzen untersucht, so dass jede von ihnen ein qualitativ und quantitativ mit dem jeder anderen vergleichbares Ergebnis liefert.

Die Grundsätze für die Wahl der Methodik habe ich an anderen Stellen (Rapp. et Proc.-Verb. Bd. 99, S. 4, Kieler Meeresforschg. Bd. 1, S. 323) dargelegt, und ich will sie hier nicht wiederholen. Es sei nur bemerkt, dass die Methodik einerseits so einfach wie möglich sein, andererseits ein möglichst repräsentatives Plankton beschaffen sollte. Ersteres (oder eigentlich beides) veranlasste die Beschränkung auf die Oberfläche, letzteres die Wahl einer Grössenordnung, die Phytoplankton und Zooplankton möglichst gleichmässig erfasst. Man könnte natürlich das hier angestrebte oder ähnliche Ziele auch auf anderen Wegen erreichen. Es sei z. B. an die Methode des "Planktonrecorders" erinnert, bei dessen Konstruktion Hardy im Grunde von dem gleichen Bestreben wie ich ausgegangen ist, die Planktonverteilung auf längeren Fahrtstrecken festzustellen, jedoch unter abweichender Bewertung der verschiedenen in Betracht kommenden Gesichtspunkte.

Ich bin mir wohl bewusst, dass man mancherlei Einwendungen gegen die Wahl meiner Methodik machen kann. Diesen Einwendungen in der hier gebotenen Kürze auch nur einigermassen gerecht zu werden, ist nicht möglich. Ich möchte nur zwei Gesichtspunkte hier zur Geltung bringen, die vielleicht geeignet sind, die Beurteilung in einigen Hauptrichtungen zu klären. Erstens gibt es eine ganze Gruppe möglicher Einwände, welche in ähnlicher Weise auch erhoben werden konnten, als man begann, Salzgehaltskarten der Meeresoberfläche herzustellen. Einwände, die sich z. B. beziehen mögen auf jahreszeitliche und jährliche Veränderungen, unperiodische Schwankungen, Verschiedenartigkeit der Beziehungen zu tieferen Wasserschichten u. dgl. mehr. Dass wir trotz solcher Schwierigkeiten tatsächlich Salzgehaltskarten besitzen, lässt erwarten, dass solche Schwierigkeiten auch bei dem Plankton überwindbar sein werden. Zweitens wird man denjenigen Einwendungen nicht allzuviel Raum geben dürfen, die aus der oben berührten Beziehung zwischen Planktonleben und Fischleben hergeleitet werden könnten, Einwendungen gegen die Brauchbarkeit der gedachten Karten für die Praxis. Was hier angestrebt wird, ist die Gewinnung einer ersten festen Basis, die, wenn sie einmal da ist, sowohl sich dauernd weiter verfestigen wird, wie auch als Unterlage für die Untersuchungen dienen wird, welche sich unmittelbar mit den Beziehungen der Planktonverteilung zum Leben der Fische befassen. Man darf von einer solchen Fundamentierung nicht mehr erwarten, als dass sie geeignet sei, darauf weiter zu bauen.

Es ist nun meine Absicht, den Versuch zu machen, mittels der besprochenen Methode Unterlagen für Planktonkarten zu beschaffen, die sich über das bisher untersuchte nicht unbedeutende Teilgebiet (60°—70° N. Br., 0°—40° W. L.) hinaus auf den ganzen Bereich der nordischen Meere erstrecken sollen, welche die Internationale Meeresforschung als ihr Arbeitsgebiet betrachtet. Nach den bisherigen Erfahrungen wird man dies Ziel nur erreichen können, wenn man Karten für bestimmte Monate herstellt. Daraus aber habe ich weiter gefolgert, dass man sich, um die Arbeit nicht zu umfangreich werden zu lassen, zunächst auf einen oder wenige Monate beschränken sollte. Ich halte dazu besonders den August für geeignet, der sich für den oben angegebenen Bereich um Island als recht zweckmässig bewährt hat, doch würde sich eine Ausdehnung der Probenbeschaffung auf die Monate Juli und September, vielleicht auch auf Juni und Mai empfehlen.

Dazu nun möchte ich die Vertreter der an der Internationalen Meeresforschung beteiligten Länder

re Unterstützung bitten, dass ich von möglichst Punkten der von ihnen im August oder auch nderen genannten Monaten befahrenen Meeres-e Planktonproben der Meeresoberfläche er-die dann unter meiner Leitung quantitativ eitet werden sollen. Das sehr einfache Gerät für Probenbeschaffung wird die Deutsche Wissen-liche Kommission für Meeresforschung, soweit ittel reichen, durch mich zur Verfügung stellen. technische Ausführung dieses Vorschlages in zweierlei Weise geschehen, einer einfacheren iner etwas mühsameren. Bei der ersteren würde n nur darum handeln, dass Aluminiumflaschen, Liter fassen und etwas konzentriertes Formalin lten, mit Oberflächenwasser gefüllt und etiket-werden. Wir haben in der Tat eine Untersuchung estlichen Ostsee mit Proben dieser Grösse bei ndung der erwähnten engmaschigen Gaze für hreszeiten erfolgreich durchführen können und len Erfahrungen etwa zwischen Island und den ndinseln werden auch dort, und somit wohl in eisten in Betracht kommenden Gebieten, so Proben im August einigermassen genügen. rhin wären etwas grössere Proben erwünscht. aben in vielen Fällen ein Wasserquantum von rn zweckmässig gefunden. Um solche grösseren n zu verwerten, müsste ein anderer Weg gen werden, nämlich die Durchseihung der fproben an Bord. Die gesamte Arbeit zur Ge-ng einer solchen Probe, wie sie vielfach nach n Anweisungen auch von Nichtbiologen, ja on technischen Hilfskräften unter wissenschaft-Leitung ausgeführt worden ist, verlangt etwa nuten Zeit und ist sehr einfach.

n eine solche, in gewissem Sinne internationale mehrere Jahre hindurch hauptsächlich in auf den Spätsommer durchgeführt werden , so wäre mit Sicherheit ein Erfolg in der benen Richtung zu erwarten. Selbst wenn das al nicht reichlich und nicht gleichmässig genug en sollte, um befriedigende Karten mit Isolinien (das ist schliesslich das Entscheidende) darauf zu gründen, so würden doch die beschafften Zahlenwerte für die einzelnen Punkte von dauerndem Wert sein, da sie absolute Werte für bestimmte Wassermassen von bestimmten Punkten darstellen, ganz entsprechend etwa den Salzgehaltswerten. Sie würden zweifellos wertvoller sein als alle quantitativen Werte, die nur auf Grund der Bauart und Verwendungsweise eines bestimmten Fangapparates verständlich und im allgemeinen deswegen nur verknüpfbar sind mit Werten, die auf dieselbe Weise gewonnen werden. Bei unserer Methodik könnte man als durch die Apparatur bedingte Einschränkung der "Absolutheit" der Werte allenfals die Maschenweite der Siebe (40 μ) bezeichnen, aber diese Einschränkung ist ja nur die Festlegung der Grössenordnung des untersuchten Planktons, eine Bestimmung, ohne die keine statistische Planktonmethode auskommt.

Um einen Anhalt zu geben für die Beurteilung des Umfanges der Arbeit, seien schliesslich noch folgende Einzelheiten mitgeteilt. Man würde im allgemeinen eine Fahrtstrecke von 500 Sm. (das entspricht etwa der Strecke von der Elbmündung bis zu den Orkneyinseln) durch etwa 25—50 Proben genügend kennzeichnen können, d. h. man würde dafür 25—50 Literflaschen brauchen oder, wenn man grössere Wassermengen an Bord durchseiht, 5—10 Arbeitsstunden nötig haben, die sich bei 10 Sm. Stundengeschwindigkeit auf 50 Stunden verteilen würden. Da es jedoch in den meisten Fällen nicht möglich sein wird, Tag und Nacht Proben zu entnehmen, so werden diese Zahlen zumeist durch längere Unterbrechungen wesentlich verringert werden. Ich möchte glauben, dass eine Arbeit von diesem Umfange, insbesondere auch, wenn die mehr oder weniger arbeitsfreien Zufahrtswege zu den eigentlichen Untersuchungsgebieten in diesem Sinne ausgenutzt würden, keine übermässige Belastung darstellt, sofern man ein internationales Interesse an der zu lösenden Aufgabe anerkennt.